Explanation for Multiple-choice Questions

FORM 4

SUMMATIVE PRACTICE 1

1 D Sodium chloride is table salt and is used in the food industry widely.

2 A The graph shows that as the concentration of the acid solution increases, the rate of the reaction increases proportionally. Thus, the concentration of the acid is the manipulated variable.

3 A The same volume of hydrogen peroxide is poured into two test tubes.
Then, the same amounts of magnesium oxide and manganese(IV) oxide are added to the test tubes, respectively.
Glowing wooden splinters is put near the mouth of each of the test tube and which test tube releases oxygen earlier is observed. This is signaled by the rekindling of the glowing wooden splinter.
Therefore, the manipulated variable is adding magnesium oxide or manganese(IV) oxide to each test tube.

4 B The concentration and temperature of reactants affect the rate of a reaction.
The higher the concentration, the higher the rate of collisions between the hydrogen peroxide particles. Thus, the rate of reaction is higher.
The higher the temperature, the faster the hydrogen peroxide molecules move, resulting in a higher rate of collisions between the molecules. Thus, the rate of reaction is higher.
Thus, if we want to study if MgO (magnesium oxide) and MnO_2 (manganese(II) oxide) affect the rate of decomposition of hydrogen peroxide, the mass of MgO and MnO_2, and the concentration and temperature of hydrogen peroxide must be kept constant.

5 B The diagram shows that a piece of Li, Na and K are added to water filled in each beaker.
The results are the different brightness of the flames produced by each reaction. Thus, the brightness of the flame is the responding variable. The different metals added is the manipulated variable. To compare the reactivity of the reaction of each metal with water, the size of each metal must be the same.
Therefore, the size of metal is the constant variable.

6 A The experiment is conducted by pouring hydrochloric acid of different concentrations into different beakers. Then, a length of magnesium ribbon is added to the first beaker and the stopwatch is started. The time for the magnesium ribbon to completely dissolve is recorded.
The experiment is repeated by adding magnesium ribbons of the same length to the HCl solutions in the different beakers.
Thus, the length of the magnesium ribbon must be the same for each experiment (I is correct) but the concentration of hydrochloric acid is manipulated (II is incorrect). The kinetic energy of the hydrogen ions is higher when the temperature of the hydrochloric acid is higher. Therefore, the rate of collisions between the hydrogen ions from HCl and the surface of the magnesium ribbon is higher, making the rate of reaction higher. Thus, the temperature of the HCl solution must be kept constant (III is correct).
The size of beakers used does not affect the rate of reaction (IV is incorrect).

7 B The volume and temperature of water used affect the solubility of salt. If we want to study the effect of volume of water on the solubility of salt, we need to manipulate the volume of water used in each beaker but the temperature of water in each beaker must be kept constant.

8 D If we want to study which solvent can dissolve polystyrene, we pour the different solvents, water and benzene, into two different boiling tubes (manipulated variable). Then, we add polystyrene to each boiling tube and stir the mixture with a glass rod. The mass of polystyrene added must be fixed (fixed variable).

9 C Adding an alkali to an acid will neutralise the acid to produce salt and water.

10 A A more reactive metal takes a shorter time to react completely with an acid solution compared to a less reactive metal.
Magnesium ribbon takes the shortest time to react. Thus, magnesium is the most reactive metal.
Iron takes the longest time to react. Thus, iron is the least reactive.
To arrange metals in increasing order of reactivity, arrange them from least reactive metal to the most reactive metal.

11 A The experiment can be conducted by pouring the same volume of water into two boiling tubes (fixed variable).
Then, add the same mass of potassium hydroxide and magnesium hydroxide into each boiling tube and stir the mixtures with glass rods and observe which substance dissolve in water (manipulated variable).

12 C The symbol is used to label explosive chemicals. Explosions during experiments might cause glass apparatus like beakers to shatter. To prevent eye injuries, students must wear goggles during experiments. Experiment involving poisonous gases are conducted in fume cupboards.

13 C The symbol is used to show that a chemical is flammable. Such chemicals must be stored away from sources of fire and fire.

14 B According to the chemical equation, chlorine gas is one of the products of the reaction. Chlorine gas is poisonous and to avoid inhaling the gas, the experiment must be conducted in a fume chamber.

15 A Diluting concentrated acid is an exothermic process where a lot of heat energy is released. Adding water to a solution of concentrated acid may cause the water to boil and causes the solution to splash out (B is incorrect).
Concentrated acid solutions are denser than water. If we pour concentrated acid solutions into water, the acid particles will flow slowly into the water. There is less risk of the resulting acid solution spilling out (A is correct).

16 D Based on the diagram, one conical flask contains bigger-sized marble chips whereas the other conical flask contains smaller-sized marble chips. The size of the marble chips is the manipulated variable. The smaller the marble chips, the bigger the total surface area of the marble exposed to acid. Therefore, the rate of collisions of acid particles with the surface of the marble chips is higher.
Based on the chemical equation, the reaction between HCl and marble chips releases carbon dioxide gas. As the reaction progresses, within the same amount of time, the mass of the conical flask containing the smaller-sized marble chips decreases more rapidly and releases a higher amount of carbon dioxide gas compared to the conical flask with the bigger-sized marble chips.

Explanation for Multiple-choice Questions

FORM 4

SUMMATIVE PRACTICE 2

1 C A substance exists in the gaseous state over its boiling point.

2 B Relative atomic mass of silver

$$= \frac{(107 \times 51.8) + (109 \times 48.2)}{100}$$

$$= \frac{5542.6 + 5253.81}{100}$$

$= 107.964$

$= 108.0$

3 C The diagram shows that the diatomic particles do not touch each other. Thus, the substance is a gas. Iron, magnesium oxide and sodium chloride are solids.

4 B Freezing is a process in which a liquid turns to solid. To freeze, the particles loses heat energy and their van der Waals forces of attraction become stronger. The particles come closer to each other before finally becoming solid where they only vibrate at fixed positions.

5 C The relative molecular mass of NH_3 is 17, whereas the RMM of HCl is 36.5. HCl is a heavier molecule and move slower than the lighter NH_3 molecules. Position **B** is the center line. Thus, the NH_3 and HCl molecules react to form white fumes of NH_4Cl at position **B**.

6 C All metals and inert gases (elements of Group 18) consist of atoms.
Iron, tin and copper are metals while helium is an inert gas.
Chlorine and nitrogen exist as diatomic molecules, Cl_2 and N_2.
A sulphur molecule consists of 8 sulphur atoms, S_8, that are chemically bonded.
A phosphorus molecule consists of 4 phosphorus atoms, P_4, that are chemically bonded.

7 A The molecules do not touch each other. Thus, before the process, the substance exists as a gas. After the process, the particles are regularly arranged, indicating a solid state. The process whereby a gas changes to solid is called deposition, during which heat energy is released.

8 B Melting is the process in which a solid changes to liquid.
Heat energy is absorbed to overcome the forces of attraction between the particles of a substance before it can melt (I is true, II and III are false).
The distance between the particles of a liquid is further that the distance between particles of a solid (IV is correct).

9 C The heavier the gas molecules, the lower the rate of diffusion of the gas out of the balloon, as a result, the balloon remains its initial size for longer.
The lighter the gas molecules, the higher the rate of diffusion of the gas out of the balloon, as a result, the balloon reduces in size faster.

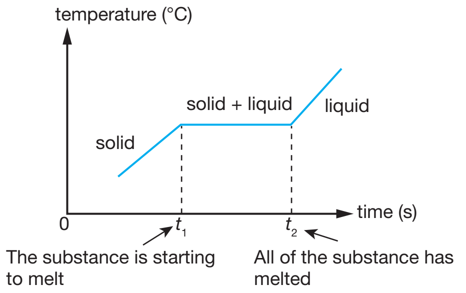
Gas	Relative molecular mass	Rate of diffusion	Size of balloon
C_4H_{10}	58	Low	Big
NH_3	17	High	The smallest
SO_2	64	Lowest	The biggest
N_2	28	Low	Small

10 B During time t_1 to t_2, the acetamide is melting where heat energy is absorbed to overcome the forces of attraction between the molecules and the molecules move further apart. The further the molecules, the weaker the forces of attraction between the molecules. Chemical bonds are only broken during a chemical reaction, not during melting.

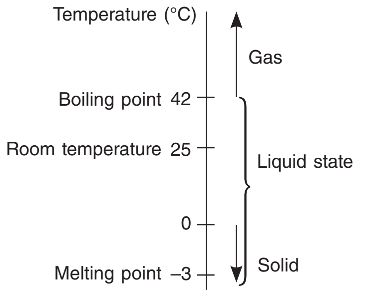
11 A Based on the diagram, before the process, the particles are arranged in a regular manner (solid state), but after the process, the particles are further apart but still in contact with each other (liquid state). Thus, the process is melting during which heat energy is absorbed to overcome the forces of attraction between the particles.

12 D Ice (solid) is heated until it boils (turns into steam/gaseous state). During melting, ice turns into water and the temperature is constant. The constant temperature is reflected on the graph as a flat line. During the boiling of water to steam, the temperature also remains constant. The constant temperature is reflected on the graph as a flat line.

13 A



14 C



Below –3°C, the substance exists as a solid. Above 42°C, the substance exists as gas.

15 B After some time, the solution turned orange. This shows that the orange dichromate(VII) ions are in random motion and diffuse throughout the solution.

16 D Air is colourless whereas bromine is a dark brown gas. Once the gas jar cover is removed, the air and bromine molecules in the jars diffuse randomly until they are evenly distributed between the gas jars. Thus, both gas jars contain light brown gas.

17 D Atomic model I shows an atom with a nucleus and electrons embedded around it. This model is suggested by Rutherford. After he bombarded a thin gold foil with alpha particles, he found that some particles are deflected, which led him to suggest that protons in the nucleus of atoms repel the positively charged alpha particles.
Thomson discovered electrons and suggested that electrons are distributed throughout an atom as shown by atomic model II.

18 A Thomson discovered electrons when he conducted an experiment using a discharge tube.
Rutherford discovered protons when he bombarded a thin gold foil with alpha particles.
James Chadwick discovered neutral particles which he then calls neutrons.
Niels Bohr showed that electrons are arranged in shells around the nucleus of atoms.

19 B Niels Bohr performed an experiment that studies the emission spectra of elements and found that each element emits emission spectra at specific wavelengths. He then suggested that electrons in atoms are arranged in shells around the nucleus.

20 C The electron arrangement given is 2.8.18.5.
The total number of electrons = 33
Thus, arsenic has 33 electrons and 33 protons.
The number of neutrons given is 42.
Therefore, the nucleon number = 33 + 42
= 75

21 D The electron arrangement of *P* is 2.2.
P have 2 valence electrons. Thus, it is in Group 2 in the Periodic Table. I is false and III is true.
The number of neutrons in *P* is 9 – 4 = 5. II is true. The electron arrangement of elements with proton number 12 is 2.8.2. The elements have two valence electrons similar to element *P*, thus have the same chemical properties. IV is true.

22 D Atom *X* releases two valence electrons during a chemical reaction and forms an ion with the charge +2.

$$X \rightarrow X^{2+} + 2e^-$$
2.8.18.18.8.2 2.8.18.18.8

Thus, both atom *X* and ion X^{2+} have 56 protons in their nucleus.
The number of neutrons in the nucleus = 81
Therefore, the nucleon number = 56 + 81
= 137

23 B Atom *Y* has 7 valence electrons.
During a chemical reaction, atom *Y* accepts an electron to achieve the stable octet electron arrangement and forms ion Y^- with the charge –1.

$$Y + e^- \rightarrow Y^-$$
2.8.18.18.7 2.8.18.18.8

Thus, both atom *Y* and ion Y^- have 53 protons.
The number of neutrons = 74
Therefore, the nucleon number = 53 + 74
= 127

24 A Aluminium atom has 13 protons, 13 electrons and 14 neutrons.
During a chemical reaction, an aluminium atom releases 3 valence electrons and forms aluminium ion, Al^{3+} that has a stable octet electron arrangement.

$$Al \rightarrow Al^{3+} + 3e^-$$
2.8.3 2.8

The number of protons and neutrons in the nucleus of the atom do not change during a chemical reaction. An aluminium ion has 13 protons, 10 electrons and 14 neutrons.

25 A Selenium atoms have 6 valence electrons. During chemical reactions, the atoms accept 2 electrons and forms selenide ions to achieve the stable octet electron arrangement.

$$\underset{2.8.18.6}{Se} + 2e^- \rightarrow \underset{2.8.18.8}{Se^{2-}}$$

An atom has the same number of protons and electrons. Thus, a selenium atom has 34 protons.

26 C The nucleon number of *X* is 17 and the proton number is 7. (I is true)
The electron arrangement of *X* is 2.5. It has 5 valence electrons. (II is true)
X belongs to Group 15 in the Periodic Table. (III is true)
Elements with the proton number 17 have 7 valence electrons and belong in Group 17. Elements of different Groups have different chemical properties. (IV is false)

27 A In an atom, the number of protons (blue) and electrons (black) are the same. The white circles represent neutrons, which are different in number. Atoms with the same number of protons but different number of neutrons are called isotopes.

28 D

Particle	Proton number	Electron arrangement	Total number of electrons	Charge of particle
P	9	2.8	10	–1
Q	19	2.8.8	18	+1

29 C Atoms with the same number of valence electrons have the same chemical properties.

Element	*P*	*Q*	*R*	*S*
Proton number	3	5	13	17
Electron arrangement	2.1	2.3	2.8.3	2.8.7

Elements *Q* and *R* each has 3 valence electrons, and therefore they have the same chemical properties.

30 C P-31 and P-32 are isotopes that have 15 protons each. I is false.
P-32 have 32 – 15 = 17 neutrons, whereas P-31 have 31 – 15 = 16 neutrons. II is true.
The heavier the atom, the denser is element. Therefore, III is true.
Both P-31 and P-32 have electron arrangement 2.8.5. Their number of valence electrons are the same. Thus, they have similar chemical properties.
IV is false.

31 B A positively charged ion is formed when an atom releases its valence electron(s) during a reaction.

$$\underset{2.8.1}{W} \rightarrow \underset{2.8}{W^+} + e^-$$

Both atom *W* and ion W^+ have 11 protons
Nucleon number
= number of protons + number of neutrons
= 11 + 12
= 23 (A is correct)

$$\underset{2.8.8.2}{Y} \rightarrow \underset{2.8.8}{Y^{2+}} + 2e^-$$

Both atom *Y* and ion Y^{2+} have 20 protons
Nucleon number
= number of protons + number of neutrons
= 20 + 20
= 40 (C is correct)

A negatively charged ion is formed when an atom accepts electron(s) during a reaction.

$$\underset{2.6}{X} + 2e^- \rightarrow \underset{2.8}{X^{2-}}$$

Both atom *X* and ion X^{2-} have 8 protons.
Nucleon number = 8 + 8
= 16 (B is incorrect)

$$\underset{2.8.7}{Z} + e^- \rightarrow \underset{2.8.8}{Z^-}$$

Both atom *Z* and ion Z^- have 17 protons.
Nucleon number = 17 + 18
= 35 (D is correct)

32 B The electron arrangement of *X* is 2.7.
The electron arrangement of *Y* is 2.8.7.
Both *X* and *Y* have the same chemical properties as both elements have 7 valence electrons.

33 C Gamma rays are electromagnetic waves with a short wavelength that can kill microbes. The ray is used to sterilise plastic hypodermic syringes and surgical gloves.

34 A Living plants take in carbon dioxide during photosynthesis. Some of the carbons in carbon dioxide are radioactive carbon-14. Carbon-14 is incorporated in the bodies of animals that eat the plants. When the plants or animals die, the carbon-14 will decay. The longer the plants or animals have died, the lesser the carbon-14 content that remains in the organisms.

35 D The electron arrangement of both $^{127}_{53}I$ and $^{131}_{53}I$ is 2.8.18.18.7.
I-127 and I-131 have different physical properties. (I is incorrect)
Each isotope has 7 valence electrons. Thus, they have the same chemical properties. (II is correct)
Isotopes of the same element have different numbers of neutrons. (III is incorrect)
Isotopes of the same element have the same number of protons. (IV is correct)

36 D Isotopes have the same number of protons but different numbers of neutrons.

$^{35}_{17}Cl$	$^{37}_{17}Cl$
17 protons	17 protons
18 neutrons	20 neutrons

37 C Sodium-24 is injected in pipes carrying flammable gas and is carried along the pipe. A Geiger Muller tube is used to detect the part of the pipe that has a leak. The part of the pipe that is leaking will show a high radiation reading on the Geiger Muller tube.

38 B Iodine-60 disintegrates and releases gamma radiations with a short wavelength. These high energy electromagnetic waves can kill cancer cells.

39 B RAM of magnesium

$$= \frac{(79 \times 24) + (10 \times 25) + (11 \times 26)}{100}$$

$= 24.32$

40 A Assume the percentage abundance of boron-11 $= x\%$
Percentage abundance of boron-10 $= (100 - x)\%$

$$\frac{10(100 - x) + 11x}{100} = 10.8$$

$$1000 - 10x + 11x = 1080$$

$$x = 1080\text{-}1000$$

$$x = 80\%$$

41 C Assume the percentage abundance of lithium-7 $= x\%$
Percentage abundance of lithium-6 $= (100 - x)\%$

$$\frac{7x + 6(100 - x)}{100} = 6.925$$

$$x = 92.5$$

42 A RAM of potassium $= \frac{39(93.26) + 41(6.74)}{100}$

$= 39.13$

43 D Assume the percentage abundance of gallium-71 $= x\%$
Percentage abundance of gallium-69 $= (100 - x)\%$

$$\frac{71x + 69(100 - x)}{100} = 69.8$$

$$x = 40\%$$

$$100 - x = 60\%$$

Explanation for Multiple-choice Questions

FORM 4

SUMMATIVE PRACTICE 3

1 B

	CO_2 gas	NO_2 gas	SO_2 gas	SO_3 gas
Number of moles, *n*	$= \frac{33.0}{[12 + 2(16)]}$ = 0.75 mol	$= \frac{36.8}{[14 + 2(16)]}$ = 0.8 mol	$= \frac{38.4}{[32 + 2(16)]}$ = 0.6 mol	$= \frac{41.6}{[32 + 3(16)]}$ = 0.52 mol
Volume at room conditions, *V*	= 0.75 mol × 22 dm^3 mol^{-1} = 16.5 dm^3	= 0.8 mol × 22 dm^3 mol^{-1} = 17.6 dm^3	= 0.6 mol × 22 dm^3 mol^{-1} = 13.2 dm^3	= 0.52 mol × 22 dm^3 mol^{-1} = 11.4 dm^3

2 B

The number of moles of butane, C_4H_{10}

$$n = \frac{2.32 \text{ g}}{(4 \times 12) + (10 \times 1)}$$
$$= 0.04 \text{ mol}$$

$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

Based on the equation, 2 moles of butane require 13 moles of oxygen gas

Hence, 0.04 moles of butane require $\frac{13}{2}$ × 0.04 moles of oxygen gas = 0.26 mol

The volume of O_2 needed = 0.26 × 22.4
= 5.82 dm^3

3 B

Formula	NH_4Cl	$CO(NH_2)_2$	$(NH_4)_3PO_4$	$(NH_4)_2SO_4$
Relative formula mass	53.5	60	149	132
Number of nitrogen atom	1	2	3	2
% mass of nitrogen	$\frac{14}{53.5} \times 100\%$ = 26.1%	$\frac{28}{60} \times 100\%$ = 46.7%	$\frac{42}{149} \times 100\%$ = 28.2%	$\frac{28}{132} \times 100\%$ = 21.2%

The mass percentage of nitrogen in urea is the highest. Thus, urea is the best nitrogenous fertiliser.

4 B Assume the relative atomic mass of element *X* = *m*

Given RFM of $K_2X_2O_7$ = 294

Therefore, 2(39) + 2*m* + 7(16) = 294
m = 52

5 A Given the RFM of $Al_2O_3.2SiO_2.xH_2O$ = 258

2(27) + 3(16) + 2[28 + 2(16)] + 18*x* = 258
54 + 48 + 120 + 18*x* = 258
18*x* = 36
x = 2

6 C Given the RFM of $M_4Fe(CN)_6$ = 368

Assume the relative atomic mass of element *M* = *a*

Therefore, 4*a* + 56 + 6(12 + 14) = 368
4*a* + 56 + 156 = 368
a = 39

7 A Relative atomic mass is based on carbon-12 as standard. C-12 is used as the standard for comparison because it is solid, easy to obtain, and the percentage of mass of C-12 isotope is high, thus not requiring separation from the C-13 and C-14 isotopes.

8 B Given the RFM of $Z_2CO_3.10H_2O = 286$

Assume RAM of metal $Z = a$

$$2a + 12 + 3(16) + 10(18) = 286$$
$$2a + 12 + 48 + 180 = 286$$
$$2a = 46$$
$$a = 23$$

Percentage mass of metal $Z = \frac{46}{286} \times 100\ \%$

$= 16.08\ \%$

9 C The molecule have 8 carbon, 8 hydrogen and 3 oxygen atoms. Its molecular formula is $C_8H_8O_3$. Thus the RMM is 8(12) = 8(1) + 3(16) = 152.

10 A Carbon form many compounds, thus is it reactive. (A is false)

11 A

Compound	C_6H_6	C_2H_4	C_3H_8	C_7H_8
RMM	78	28	44	92
Number of carbon atoms	6	2	3	7
Percentage mass of carbon	$\frac{6 \times 12}{78} \times 100\%$ = 92.3%	$\frac{2 \times 12}{28} \times 100\%$ = 85.7%	$\frac{3 \times 12}{44} \times 100\%$ = 81.8%	$\frac{7 \times 12}{92} \times 100\%$ = 91.3%

12 A A vitamin C has molecule have 6 carbon, 8 hydrogen and 6 oxygen atoams. Its molecular formula is $C_6H_8O_6$. RMM of $C_6H_8O_6$ is 6(12) + 8(1) + 6(16) = 176.

Number of molecules in 0.88 g of vit C is

$\frac{0.88}{176} \times 6.02 \times 10^{23} = 3.01 \times 10^{21}$.

13 B Carbon-12 is used as a standard for mole.

Thus, 1 mole of a substance contains the same number of particles as 12.00 g of carbon-12.

14 C RMM of urea, $CO(NH_2)_2 = 12 + 16 + 2[(14 + 2(1)]$

$= 60$

There are 2 nitrogen atoms in urea.

The percentage mass of nitrogen $= \frac{28}{60} \times 100\%$

$= 46.67\%$

15 D $Fe_2O_3 \rightarrow 2Fe$

$2(56) + 3(16) \rightarrow 2 \times 56$

160 g of Fe_2O_3 produce 112 g Fe

Therefore, 8 g of iron(III) oxide should produce

$\frac{8}{160} \times 112$ g of iron = 5.6 g iron

But 4.48 g of iron was obtained in the experiment.

Thus, the percentage yield of iron

$= \frac{\text{experimental yield}}{\text{theoretical yield}} \times 100\%$

$= \frac{4.48}{5.6} \times 100\%$

$= 80\%$

16 A

Compound	C_2H_4	C_3H_8	CH_3COOCH_3	C_2H_5OH
RMM	28	44	74	46
Percentage mass of carbon	$\frac{24}{28} \times 100\%$ = 85.7%	$\frac{36}{44} \times 100\%$ = 81.8%	$\frac{36}{74} \times 100\%$ = 48.6%	$\frac{24}{46} \times 100\%$ = 52.2%

17 B The mass of 1 mole of caffeine is $\frac{1}{0.025} \times 4.85$ g

= 194. Thus, the relative molecular mass of caffeine is 194. Therefore, the RMM of $C_8H_{10}N_4O_2$ is 194.

18 A The RMM of tartaric acid, $C_4H_6O_6 = 150$

The number of moles in 0.75 g tartaric acid

$= \frac{0.75}{150}$ mol

$= 0.005$ mol

The number of molecules in 0.005 mole of tartaric acid $= 0.005 \times 6.02 \times 10^{23}$

$= 3.01 \times 10^{21}$ molecules

19 D The RMM of methane, CH_4 = 16

The number of moles in 0.8 g of $CH_4 = \frac{0.8}{16}$ mol

$= 0.05$ mol

The number of molecules in 0.05 mole of $CH_4 = 0.05 \times 6.02 \times 10^{23}$

One CH_4 molecule has one carbon atom and 4 hydrogen atoms, a total of 5 atoms.

Thus, the total number of atoms in methane

$= 5 \times 0.05 \times 6.02 \times 10^{23}$

$= 1.505 \times 10^{23}$ atoms

20 C The RMM of sucrose, $C_{12}H_{22}O_{11}$ = 342

The number of moles containing 7.525×10^{22} sucrose molecules $= \frac{7.525 \times 10^{22}}{6.02 \times 10^{23}}$ mol

$= 0.125$ mol

1 mole of sucrose = 342 g

0.125 mole of sucrose = 0.125×342 g

= 42.75 g

21 B The RMM of methyl isocyanate, CH_3NCO = 57

1 mole of gas occupies 22.4 dm^3 at STP

1.12 dm^3 methyl isocyanate gas $= \frac{1.12}{22.4}$ mol

$= 0.05$ mol

1 mole of CH_3NCO = 57 g

0.05 mole of CH_3NCO = 0.05×57 g

= 2.85 g

22 C 1 kg of O_2 = 1000 g. RMM of O_2 = 32.

1 mole of O_2 = 32 g. Thus, 32 g of O_2 occupies a volume of 24 dm^3 at room conditions.

1000 g of O_2 will occupy a volume of $\frac{1000}{32} \times$ 24 dm^3 = 750 dm^3.

23 A 1 mole of carbon monoxide, CO = 28 g

700 g of CO $= \frac{700}{28}$ mol

= 25 mol

1 mole of gas occupies 24 dm^3 at room conditions.

25 moles of CO = 25×24 dm^3

= 600 dm^3

24 B 0.005 mole of paracetamol = 0.755 g

Thus, 1 mole of paracetamol

$= \frac{1 \text{ mol}}{0.005 \text{ mol}} \times 0.755$ g

= 151 g

The relative molecular mass of paracetamol = 151

RMM of $C_8H_9NO_2$ = 8(12) + 9(1) + 14 + 2(16)

= 151

25 C 0.02 mole of allicin, $C_6H_{10}OX_2$ = 3.24 g

1 mole of allicin $= \frac{1}{0.02} \times 3.24$ g

= 162 g

Thus, the RMM of allicin, $C_6H_{10}OX_2$ = 162

Assume the relative atomic mass of element X = m

$6(12) + 10 + 16 + 2m = 162$

$2m = 64$

$m = 32$

26 B Substances with the same number of moles contain the same number of molecules.

4.5 g of water, $H_2O = \frac{4.5}{18}$ mol

= 0.25 mol

Substance	CO_2	C_2H_5OH	CH_3COOH	CCl_2F_2
RMM	44	46	60	121
Mass	8.8 g	11.5 g	12.0 g	30.25 g
Number of moles	$\frac{8.8}{44}$ = 0.2 mol	$\frac{11.5}{46}$ = 0.25 mol	$\frac{12}{60}$ = 0.2 mol	$\frac{30.25}{121}$ = 0.25 mol
	I is incorrect	II is correct	III is incorrect	IV is correct

27 A 1.2 dm^3 of gas X = 3.2 g

1 mole of gas (24 dm^3) $= \frac{24}{1.2} \times 3.2$ g

= 64 g

Gas	SO_2	CO_2	C_3H_8	C_4H_{10}
RMM	32 + 2(16) = 64	12 + 2(16) = 44	3(12) + 8(1) = 44	4(12) + 10(1) = 58

28 D 1 mole of gas occupies 22.4 dm^3 at STP.

5.6 dm^3 SO_2 $= \frac{5.6}{22.4}$ mol

= 0.25 mol

RMM of SO_2 = 64
Mass of 0.25 mole of SO_2
= 0.25 × 64 g = 16 g
RMM of CO_2 = 44

Mass of 8.4 dm^3 CO_2 = $\frac{8.4}{22.4} \times 44$ g
= 16.5 g

RMM of CO = 28

Mass of 14 dm^3 CO = $\frac{14}{22.4} \times 28$ g
= 17.5 g

RMM of CH_4 = 16

Mass of 16.8 dm^3 CH_4 = $\frac{16.8}{22.4} \times 16$ g
= 12.0 g

29 C 3.01×10^{22} morphine molecules has a mass of 14.25 g
6.02×10^{23} morphine molecules has a mass of

$\frac{6.02 \times 10^{23}}{3.01 \times 10^{22}} \times 14.25$ g = 285 g

1 mole of morphine has mass of 285 g
RMM of morphine, $C_xH_{19}NO_3$ = 285
$12x + 19(1) + 14 + 3(16) = 285$
$12x = 204$
$X = \frac{204}{12}$
$= 17$

30 D 1.204×10^{26} chlorine molecules
$= \frac{1.204 \times 10^{26}}{6.02 \times 10^{23}}$ mol
= 200 mol
Volume of 200 moles of chlorine gas
= 200 × 24 dm^3 at room conditions
= 4800 dm^3

31 A 1 mole of gas occupies a volume of 22 400 cm^3 at STP
Number of moles in 280 cm^3 of CO_2
$= \frac{280}{22\,400}$ mol
= 0.0125 mol
Number of gas molecules = $0.0125 \times 6.02 \times 10^{23}$
$= 7.525 \times 10^{21}$

32 A The molecular formula for malic acid is $C_4H_6O_5$
RMM of malic acid is 4(12) + 6 + 5(16) = 134
The number of moles in 0.335 g of malic acid
$= \frac{0.335}{134}$ mol
= 0.0025 mol
The number of molecules in 0.0025 mol
$= 0.0025 \times 6.02 \times 10^{23}$
$= 1.505 \times 10^{21}$

33 B

Element	Sb	O
Mass	x gram	0.48 gram
Number of moles	$\frac{x}{122}$ mol	$\frac{0.48}{16}$ = 0.03 mol
Simplest ratio	2	3

$$\frac{\frac{x}{122}}{0.03} = \frac{2}{3}$$
$$\frac{x}{122} = \frac{2}{3} \times 0.03$$
$$x = 122 \times 0.02$$
$$= 2.44$$

34 D The molecular formula for a vitamin A molecule is $C_{20}H_{30}O$.
RMM of vitamin A is 20(12) + 30 + 16 = 286
The number of moles containing 4.515×10^{22} molecules $= \frac{4.515 \times 10^{22}}{6.02 \times 10^{23}}$ mol
= 0.075 mol
1 mole of vitamin A = 286 g
Therefore, 0.075 mole of vitamin A
= 0.076 × 286 g
= 21.45 g

35 C The relative formula mass of $Ba(OH)_2$
= 137 + 2(16 + 1)
= 171

3.42 g of $Ba(OH)_2$ = $\frac{3.42}{171}$ mol
= 0.02 mol

$Ba(OH)_2 \rightarrow Ba^{2+} + 2OH^-$
1 mol   1 mol   2 mol

1 mole of barium hydroxide ionises in water to produce a total of 3 moles of ions.
0.02 mole of barium hydroxide ionises to produce 0.02 × 3 mol of ions = 0.06 mol
The number of ions in the solution
$= 0.06 \times 6.02 \times 10^{23}$
$= 3.612 \times 10^{22}$ ions

36 B 3 g of carbon contain $\frac{3}{21}$ mol = $\frac{1}{4}$ mol

2 g magnesium contain $\frac{2}{24}$ mol = $\frac{1}{21}$ mol

$\frac{1}{4}$ mol carbon contains m atoms

$\frac{1}{12}$ mol magnesium contains $\frac{\frac{1}{12}}{\frac{1}{4}} \times m$ atoms

$= \frac{1}{12} \times \frac{4}{1}\, m$ atoms

$= \frac{m}{3}$ atoms

37 A RFM of NaF = 23 + 19 = 42

5.25 g of NaF = $\frac{5.25}{24}$ mol

= 0.125 mol

From the eqaution NaF $\rightarrow$ Na^+ + F^-, thus 0.125 mol of sodium fluoride produces 0.125 mol of fluoride ions.

The mass of 0.125 mol of fluoride ions

= 0.125 × 19 g

= 2.375 g

38 B

Element	H	B	O
Percentage	4.8%	17.7%	77.5%
Number of mole	$\frac{4.8}{1}$ mol = 4.8 mol	$\frac{17.7}{11}$ mol = 1.61 mol	$\frac{77.5}{16}$ mol = 4.84 mol
Simplest ratio	$\frac{4.8}{1.61}$ = 3 mol	$\frac{1.61}{1.61}$ = 1 mol	$\frac{4.84}{1.61}$ = 3 mol

The empirical formula is H_3BO_3

39 C $CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$

1 mole of CuO produces 1 mole of $Cu(NO_3)_2$

So, 80 g CuO produce 188 g $Cu(NO_3)_2$

Thus, 10 g of CuO will produce × 188 g

$Cu(NO_3)_2$ = 23.5 g

40 D *M* oxide = Metal *M* + oxygen

3.8 g = 2.6 g + mass of oxygen

= 1.2 g

Element	*M*	O
Mass	2.6 g	1.2 g
Number of mole	$\frac{2.6}{52}$ = 0.05 mol	$\frac{1.2}{16}$ = 0.075 mol
Simplest ratio	$\frac{0.05}{0.05}$ = 1 mol 2 × 1 = 2 mol	$\frac{0.075}{0.05}$ = 1.5 mol 2 × 1.5 = 3 mol

The empirical formula is M_2O_3

41 C Assume relative atomic mass of metal *Y* = *m*

Element	*Y*	Cl
Mass	5.76 g	17.04 g
Number of mole	$\frac{5.76}{m}$ mol	$\frac{17.04}{35.5}$ = 0.48 mol
Simplest ratio	1 mol	4 mol

The empirical formula is YCl_4

$$\frac{\frac{5.76}{m}}{0.48} = \frac{1}{4}$$

$$\frac{5.76}{m} = \frac{0.48}{4}$$

$$\frac{5.76}{m} = 0.12$$

$$m = \frac{5.76}{0.12}$$

$$= 48$$

42 C

Element	*M*	O
Mass	*a* g	4.8 g
Number of mole	$\frac{a}{55}$ mol	$\frac{4.8}{16}$ = 0.3 mol
Simplest ratio	2 mol	3 mol

The empirical formula is M_2O_3

$$\frac{\frac{a}{55}}{0.3} = \frac{2}{3}$$

$$\frac{a}{55} = \frac{2}{3} \times 0.3$$

$$\frac{a}{55} = 0.2$$

$$a = 0.2 \times 55 \text{ g}$$

$$= 11 \text{ g}$$

43 B Combustion of hydrocarbon produces carbon dioxide and water.

$C_2H_4(g)$ + $3O_2(g)$ $\rightarrow$ $2CO_2(g)$ + $2H_2O(l)$

1 mol 2 mol

From the equation, 1 mole of ethene produces 2 moles of carbon dioxide.

Thus, 28 g of C_2H_4 produces 2 × 24 dm^3 of $2CO_2$ at room conditions.

If 9.6 dm^3 of CO_2 is produced, the mass of

ethene burned = $\frac{9.6 \cancel{dm^3}}{2 \times 24 \cancel{dm^3}} \times 28$ g

= 5.6 g

44 D Reactions between metals and acids produce salts and hydrogen gas.
Zinc reacts with hydrochloric acid to produce zinc chloride salt and hydrogen gas.
$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$
From the equation, 1 mole of zinc produces 1 mole of hydrogen gas.
Thus, 65 g of Zn produce 22.4 dm^3 (22 400 cm^3) H_2 gas at STP.
448 cm^3 of H_2 gas is produced by
$\frac{448 \cancel{cm^3}}{22\ 400 \cancel{cm^3}} \times 65$ g of Zn when it reacts with excess HCl is = 1.300 g

45 A The molecular formula of potassium oxide is K_2O
Equation: $4K(s) + O_2(g) \rightarrow 2K_2O(s)$
4 moles of potassium produce 2 moles of potassium oxide.
(4×39) g of K produces $2(39 + 39 + 16)$ g of K_2O. Therefore, 156 g of K produces 188 g of K_2O
7.8 g of K will produce $= \frac{7.8}{156} \times 188$ g
= 9.4 g of K_2O

46 B Hydrogen peroxide, H_2O_2, decomposes to produce water and oxygen gas.
Equation: $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$
2 moles of H_2O_2 produce 1 mole of O_2 gas.
2 moles of H_2O_2 produce 24 dm^3 of O_2 gas at room conditions.
Thus, 0.2 mole of H_2O_2 will produce
$= \frac{0.2 \cancel{mol}}{2 \cancel{mol}} \times 24\ dm^3$
= 2.4 dm^3 of O_2 gas

47 D During a combustion reaction, a chemical reacts with oxygen from the atmosphere.
Equation:
$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$
1 mole of C_2H_5OH needs 3 moles of O_2 for a complete combustion.
Therefore, 46 g of C_2H_5OH need $3 \times 22.4\ dm^3$ of O_2 for a complete combustion.
Thus, 9.2 g of C_2H_5OH need
$= \frac{9.2 \cancel{g}}{46 \cancel{g}} \times 3 \times 22.4\ dm^3$ of O_2 for a complete combustion
= 13.44 dm^3

48 C The chemical formula of chromium(III) oxide is Cr_2O_3
Equation:
$2Cr_2O_3(s) + 3C(s) \rightarrow 4Cr(s) + 3CO_2(g)$
2 moles of Cr_2O_3 produce 4 moles of Cr metal.
$2[2(52) + 3(16)]$ of Cr_2O_3 produce 4 x 52 g of Cr. Therefore, 304 g of Cr_2O_3 produce 208 g of Cr
Thus, 7.6 g of Cr_2O_3 will produce $= \frac{7.6}{304} \times 208$
= 5.20 g of Cr

49 A *Note*: Potassium hydroxide is an alkali, whereas carbon dioxide is an acidic gas.
The neutralisation reaction will produce potassium carbonate salt and water.
Equation:
$2KOH(aq) + CO_2(g) \rightarrow K_2CO_3(s) + H_2O(l)$
2 moles of KOH produce 1 mole of K_2CO_3
$2(39 + 16 + 1)$ g of KOH produce $2(39) + 12 + 3(16)$ g of K_2CO_3.
Therefore, 112 g of KOH produces 138 g of K_2CO_3
When 11.2 g of KOH reacts with carbon dioxide, the mass of potassium carbonate produced is $\frac{11.2}{112} \times 138$ g of K_2CO_3 = 13.8 g

Explanation for Multiple-choice Questions

FORM 4

SUMMATIVE PRACTICE 4

1 C Going down Group 17, the increase in molecular size will cause the attraction force between molecules to become stronger. Thus, the melting point and boiling point of the elements also increase because more heat energy is required to overcome the intermolecular forces. The density of elements also increases with the increase in mass when going down the Group. However, the electronegativity decreases as the electron valence are further from the nucleus going down the Group.

2 B Aluminium is in Period 3 and a transition element, hence its oxide can react with both nitric acid and sodium hydroxide solution.

3 C Group 1 elements are called alkali metals.
Group 2 elements are called alkali earth metals.
Group 17 elements are called halogens.
Group 18 elements are called inert gases.

4 B The proton number of element *Y* is
27 – 14 = 13
Element *Y* have 13 protons, and therefore has 13 electrons.
The electron arrangement of atom *Y* is 2.8.3.
It has 3 valence electrons.

5 C The '*x*' in the diagram represents the electrons of element *W*.
Element *W* have 6 valence electrons.
Thus, element *W* belongs to Group 10 + 6 = 16

6 B The proton number of element *X* is
31 – 16 = 15
Element *X* has 15 protons, and therefore has 15 electrons.
Its electron arrangement is 2.8.5.
The group number of element *X* is 10 + 5 = 15
Element *X* belongs to Period 3 because it has three filled electron shells.

7 D

Element	$_{2}W$	$_{8}X$	$_{18}Y$	$_{20}Z$
Proton number	2	8	18	20
Number of electrons	2	8	18	20
Electron arrangement	2	2.6	2.8.8	2.8.8.2
Group	18 Inert	16	18 Inert	2

Note: Element *W* is helium, *X* is oxygen, *Y* is argon and *Z* is calcium. It is advised to memorise the atomic number of the first 20 elements to be able to identify the elements.
X is diatomic/oxygen exist as diatomic molecule, O_2.
Y is inert and will not react with element *X*.
W is inert and will not react with element *X*.
W and *Y* are inert and will not react with each other.

8 B Helium has achieved a stable duplet electron arrangements. It does not need to accept, release or share electrons with other elements

9 C The element below krypton is xenon. Both elements are Group 18 elements.
All Group 18 elements are chemically inert, and thus, exist as monoatomic because its outermost electron shell are fully filled.
All Group 18 elements are gases at room conditions.

10 A As we go down Group 18, the relative atomic mass increases. As density is $\frac{\text{mass of atom}}{\text{volume of atom}}$, density increases when going down the Group. (I is true)
All Group 18 elements are inert. (II is false)
Group 18 elements do not have free moving valence electrons unlike metals. They cannot conduct electricity. (III is true)
Electronegativity is the measurement of tendency of an element to attract electron(s). All Group 18 elements have filled their outermost electron shells and do not attract electrons from other elements to form chemical bonds. They are not electronegative. (IV is false)

11 D Electron arrangement of *X* is 2.8. It has achieved a stable octet electron arrangement. *X* and *Y* will not react with each other.

12 B Electron arrangement of argon is 2.8.8. Its outermost electron shell is filled with 8 electrons and do not need to accept, donate or share electron(s) with other elements to form a compound.

13 B The lower the element in the Group, the bigger the atomic radius, and thus the valence electron is further from the nucleus. The further the electron, the weaker the electrostatic force of attraction between the electron and the protons in the nucleus. Thus, Rb can release its valence electron more easily and is more reactive.

14 D Electron arrangement of Na = 2.8.2 and K = 2.8.8.1
Na and K each has one valence electron. During chemical reactions, each will release one valence electron to achieve a stable octet electron arrangement.
The atomic radium of potassium is larger than sodium. The electrostatic forces of attraction between the nucleus and valence electrons in potassium atoms is weaker compared to sodium atom. Potassium atoms release their valence electrons more easily.

15 C

^{7}Li	2.1
^{23}Na	2.8.1
^{39}K	2.8.8.1

As we go down the Group, the atomic mass increases. Thus, density also increases. (I is true)
As we go down the Group, the atomic radius increases. Electrostatic forces of attraction between valence electrons and nucleus become weaker. Elements below the Group release their valence electrons more easily; therefore reactivity increases when going down the Group. (II is true)
Metallic bonding between atoms become weaker as we go down the Group. Thus, boiling point decreases down the Group. (III is false)
Electropositivity is the measurement of how easily an atom releases electron(s) to form a positively charged ion (cation). As the elements towards the bottom of the Group release their valence electrons more easily, electropositivity increases down the Group. (IV is true)

16 A Element *X* is lithium with the electron arrangement 2.1.
Lithium burns in air to form lithium oxide, which is soluble in water. (I is true)
Lithium reacts with water to produce lithium hydroxide, LiOH, and hydrogen. (II is false)
Lithium reacts with chorine to form lithium chloride salt, LiCl. (III is true)
Lithium is in Period 2 because it has two filled electron shells. (IV is false)

17 D Alkali metals are very reactive and react with oxygen in the air to form metal oxides.

18 A Aqueous copper(II) sulphate solution contains water. When sodium is added, it reacts with water to form sodium hydroxide and hydrogen gas.
$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$
Sodium will not displace the copper.

19 B All oxides of alkali metals are soluble in water.
$Cs_2O(s) + H_2O(l) \rightarrow 2CsOH(aq)$

20 C Group 17 elements accept a electron during reaction. The lower the element in Group 17, the larger the atomic radius. Thus, the electrostatic force attraction between electron and protons is weaker. As *X* is below chlorine, it has lower tendency to attract electron, and is thus less reactive. All halogens react with iron to form iron(III) halides.

21 A Fluorine is an element is Group 17. It has 7 valence electrons and accepts an electron during chemical reactions.

$^{19}_{9}F$ + e^-	$\rightarrow$	$^{19}_{9}F^-$
2.7		2.8
9p		9p
10n		10n
$9e^-$		$10e^-$

Fluoride ions have 10 electrons and 9 protons.

22 D Electrogenativity is a measurement of an element to attract electron. As iodine is lower than bromine, its atomic radius is larger than atomic radius of bromine. Iodine atom has lower tendency to attract electron.

23 B An example of Group 16 element is oxygen, O_2, which when dissolved in water, does not produce acidic solution.
An example of Group 17 element is chlorine, Cl_2, which when dissolved in water, produces hydrochloric acid and hypochlorous(I) acid.
$Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$
Hydrogen ions from the acids react with carbonate ions to produce carbon dioxide gas.
$2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$
Group 1 elements (such as Na) react with water

to produce alkali solutions which do not react with carbonate ions.

24 B All sodium halide salts are soluble in water. (I is true)
Bromine is a liquid at room temperature. (II is false)
Bromine dissolves in water producing hydrobromic acid and hypobromous(I) acid.
$Br_2(g) + H_2O(l) \rightarrow HBr(aq) + HOBr(aq)$
Hypobromous acid bleach/decolourise litmus papers. (III is true)
Bromine reacts with iron to produce brown iron(III) bromide salt. (IV is true)
$2Fe(s) + 3Br_2(g) \rightarrow 2FeBr_3(s)$

25 A Density and melting point do not show a regular increase across Period 3. (I and II false)
Atomic radius decreases across the Period because proton number increases. The electrostatic forces of attraction between protons and electrons become stronger causing the atomic radius to decrease. (III is false)
Elements on the left are metals and donate electrons during reactions, making them electropositive.
Elements on the right are non-metals and receive electrons during reaction, making them electronegative. (IV is true)

26 C

Group	1	2		13	14	15	16	17	18
								X (Such as $_9F$)	*Y* (Such as $_{10}Ne$)
	Z (Such as $_{11}Na$)		Transition metals						

Fluorine/*X* is more electronegative than sodium. (I is true)
Sodium/*Z* is a metal and conducts electricity, whereas fluorine/*X* is a non-metal and cannot conduct electricity. (II is true)
Metallic oxide is basic, whereas non-metallic oxide is acidic. (III is true)
Sodium/*Z* and fluorine/*X* reacts to form sodium fluoride, NaF. (IV is false)

27 C Oxides that react with both acid and alkali solutions are amphoteric oxide, which are in the middle of the periodic table. Examples of amphoteric oxides al aluminium oxide, lead oxide and tin oxide.

28 D Amphoteric oxides react with acid and alkali solutions. Thus, the elements that form amphoteric oxides are between metals (elements on the left side of the Periodic Table) and non-metals (elements on the right side of the Periodic Table). Some elements in Groups 13 and 14 form amphoteric oxides.

29 D Protons are positively charged, whereas electrons are negatively charged. As the number of protons increases, the forces of attraction between the protons in the nucleus and electrons become stronger, causing the atomic radius to decrease across a Period.

30 B *X*, *Y*, *Z* are elements in the same Period. As the proton number increases, atomic radius decreases.
The smaller the atomic radius of an element, the higher its tendency to accept electron(s).

31 A Transition elements catalyse chemical reactions, form coloured compounds, have variable oxidation states and form complex ions.

32 C QCl_2: Oxidation state of element *Q* is +2.
QCl_3: Oxidation state of element *Q* is +3.
Q has more than one oxidation number. Thus, it is a transition element.

33 D Chromate(VI) ion is yellow, whereas dichromate(VI) ion is orange.

34 B All metals conduct electricity. The difference between transition metals and other Group metals is transition metals have high densities.

35 A Pure transition metals are soft because their atoms slide over each other easily. During the alloying process, different elements are added to pure metals. The foreign atoms prevent the pure metal atoms from sliding over each other easily, making alloys harder than their pure metals.

Explanation for Multiple-choice Questions

FORM 4

SUMMATIVE PRACTICE 5

1 C Argon is in Group 18 and it has an octet electron arrangement. Argon does not form chemical bonds.

2 B Electron arrangement of *P* is 2.8.8.2. Hence, atom *P* forms P^{2+} ions by losing 2 electrons.

3 C In the formation of ionic bonds, the metal atoms donate valence electrons to non-metal atoms to achieve the stable electron arrangement of duplet or octet.

4 D The electron arrangement of X^{+} is 2.8.8. after donating 1 electron. Hence, atom *X* has an electron arrangement of 2.8.8.1 with a proton number of 19.
The electron arrangement of Y^{2-} is 2.8.8. after receiving 2 electrons. Hence, atom *Y* has an electron arrangement of 2.8.6 with a proton number of 16.

5 B Atom *P* is a non-metal with 4 valence electrons and atom *Q* is a non-metal with 6 valence electrons. Both atoms need to share electrons to achieve the stable octet electron arrangement, forming a covalent bond.

6 B *U* and *T* are both non-metal atoms and share valence electrons to achieve octet electron arrangement. *U* will share 3 valence electrons while *T* will share 1 valence electron to form UT_3

7 D Both *X* and *Y* are non-metals that shared valence electrons to achieve the octet electron arrangement. The electron arrangement of atom *Y* is 2.6. *Z* with an electron arrangement of 2.8.2 can donate 2 valence electrons to atom *Y* to form an ionic bond. Atom *Z* will form Z^{2+} ion, while *Y* will form Y^{2-} ion in the ionic compound formed.

8 C $X + 2e^{-} \rightarrow X^{2-}$

9 C The electron arrangement of option **C** is 2.8.6, the element shares 2 valence electrons or accepts 2 valence electrons to achieve the octet electron arrangement. The element in option **A** can only form covalent bonds, while the elements from options **B** and **D** are metals that form ionic bonds.

10 C N atom contributes a pair of unshared electrons to be shared with a B atom to achieve the stable octet electron arrangement, forming a dative bond.

11 B Hydrogen bonds are formed between hydrogen atoms bonded to very electronegative atoms, such as F, N and O, and other very electronegative atoms. Br, Cl and C in options **A** and **C** are not electronegative enough. A hydrogen bond is not formed between H and H in option **D**.

12 A O atom in H_2O contributes a pair of unshared electrons to be shared with H^{+} to form a dative bond in H_3O^{+}.
N atom in NH_3 contributes a pair of unshared electrons to be shared with H^{+} to form a dative bond in NH_4^{+}.
No dative bond is formed in SO_4^{2-} and CO_3^{2-}.

13 C Covalent compounds such as glucose, are soluble in water because these compounds form hydrogen bonds with water molecules.

14 B Butane has only weak van der Waals force of attraction between its molecules. Oxygen is very electronegative and induces partial positive charge in hydrogen, H, in water molecules to form hydrogen bonds.

15 D Calcium is a metal that contains delocalised electrons that can move freely in metallic bonds.
Calcium (a metal) forms an ionic bond with chlorine (a non-metal) in calcium chloride.
Ionic compounds have ions that are attracted strongly by ionic bonds in the solid state and hence cannot conduct electricity.
The ionic bonds are overcome by heat energy in the molten state, therefore the ions are free to move to conduct electricity.

16 C Organic solvents can dissolve naphthalene, which is an organic compound. However, organic solvents, like other organic compounds, have low boiling points and do not dissociate in water and conduct electricity.

17 A *W* is a metal and *Z* is a non-metal that react to form an ionic compound with a high melting point.

18 D *E* (with the electron arrangement 2.8.8.1) and *D* (with the electron arrangement 2.8.7) react to form an ionic compound that conducts electricity in its liquid state.

19 C *P* (with the electron arrangement 2.8.2) and *Q* (with the electron arrangement 2.8.6) react to form *PQ*.
Relative molecular mass = the sum of the nucleon numbers of respective element = 24 + 32
= 56

20 C *S* (2.8.1) is a metal and *U* is a non-metal (2.8.6) that react to form an ionic compound with a high melting point and boiling point. *T* (2.8.4) can only form covalent compounds.

21 D Electrical conductivity in liquid state can be used to differentiate between potassium chloride (an ionic compound) and glucose (a covalent compound).

22 B The compound formed shows shared electrons in their overlapped valence electron shells, indicating it is a covalent compound.

Explanation for Multiple-choice Questions

FORM 4

SUMMATIVE PRACTICE 6

1 A Ammonia does not dissociate to ions, and exists as molecules in organic solvents (such as propanone).

2 B Sulphurous acid and carbonic acid are both weak acids. Phosphorous acid is a triprotic acid.

3 D Limewater is calcium hydroxide, which is alkaline (pH more than 7).

4 B Zinc, a metal, reacts with acids, including sulphuric acid, to release hydrogen gas that fills up the balloon. Options **A** and **D** will not produce reactions, while option **C** will only produce ammonia gas when heated.

5 B pH = –log [H^+]
= –log 0.001
= 3

6 D 0.1 mol of $Ba(OH)_2$ produces 0.2 mol of OH^-
pOH = –log [OH^-]
= –log (0.1 × 2)
= 0.7
pH = 14 – 0.7 = 13.3

7 B pH = –log [H^+],
2 = –log [H^+]
[H^+] = 0.01 mol dm^{-3}

8 B Both *P* and *Q* are alkalis as they are soluble in water to form solutions. Solution *P* has a lower pH, indicating it is a weak alkali that ionises partially to produce a lower concentration of hydroxide ions (hence a higher concentration of hydrogen ions) than solution *Q*.

9 A The diagram shows only some ammonia molecules, NH_3 (compound *X*), which undergo ionisation to produce hydroxide, OH^- ions. This indicates that compound *X* is a weak alkali that undergoes partial ionisation to produce a low concentration of hydroxide ions.

10 D Ethanoic acid is a weak acid that has a lower degree of ionisation, a lower concentration of H^+ ions and a higher pH value compared to HCl. But both aids are monoprotic acids that react with the same number of moles of OH^- ions.

11 C Only KOH is a strong alkali that undergoes complete dissociation to produce a high concentration of OH^- ions. The rest are weak bases that undergo partial dissociation.

12 D The lower the pH value, the higher the concentration of H^+ ions, and hence the higher the degree of dissociation. Ascending order of dissociation is associated with descending order of pH values.

13 C Molecular mass of NaOH = 23 + 16 + 1 = 40

$$\text{Mass of NaOH} = \frac{MV}{1000} \times 40 = \frac{0.5 \times 250}{1000} \times 40 = 5.0 \text{ g}$$

14 C

$$M_1V_1 = M_2V_2$$
$$2.0 \times 30 = M_2 \times 250$$
$$M_2 = \frac{2.0 \times 30}{250}$$
$$= 240 \text{ cm}^3$$
$$= 0.24 \text{ dm}^3$$

15 C Using the formula $M_1V_1 = M_2V_2$, where M_1 is the initial molarity, M_2 is the final molarity, V_1 is the initial volume, and V_2 is the final volume to calculate.

$$M_2 = \frac{1.0 \times 2.0}{100} = 0.2 \text{ mol dm}^{-3}$$

Option **A** produces 0.1 mol dm^{-3} sulphuric acid. V_2 of option **B** is 110 cm^3, while M_1 of option **D** is 90 cm^3.

16 D

$$\frac{M_AV_A}{M_BV_B} = \frac{2}{1}$$
$$M_A = \frac{2 \times 1.0 \times 25}{1000}$$
$$= 0.625 \text{ mol dm}^{-3}$$

17 B

$$\text{Number of mol of } X = \frac{0.5 \times 25}{1000} = 0.0125$$

$$\text{Number of mol of NaOH} = \frac{1.0 \times 25}{1000} = 0.025$$

0.0125 mol of *X* reacts with 0.025 mol of NaOH
Hence 1 mol of *X* reacts with 2 mol of NaOH
This means *X* is a diprotic acid. H_2SO_4 is the only diprotic acid in the answer options.

18 B Magnesium sulphate is a soluble salt that can be prepared by reacting an acid (sulphuric acid) and a metal, metal oxide, or metal carbonate. There is no reaction between sulphuric acid and magnesium chloride.

19 B $PbSO_4$ is an insoluble salt that can be prepared by the double decomposition reaction. The rest are soluble salts.

20 A Salt *P* is barium sulphate, which is an insoluble salt. Only lead(II) nitrate reacts with sodium sulphate to produce lead(II) sulphate, which is also an insoluble salt.

21 C *R* is a residue, indicating that it is an insoluble salt formed by the double decomposition reaction between solution *P* and solution *Q*. $MgCO_3$ is the only insoluble salt.

22 C Zinc nitrate is a soluble salt that can be prepared by reacting nitric acid and a metal carbonate. Hence, salt *Y* is magnesium carbonate and solution *X* is an insoluble carbonate (calcium carbonate) used in excess to ensure all the nitric acid is completely reacted. Potassium carbonate is a soluble carbonate and can not be removed from zinc nitrate solution.

23 C Let the molarity of $Pb(NO_3)_2$ solution $= x$ mol dm^{-3}

Number of mol of $Pb^{2+} = \dfrac{x \times 5}{1000} = 0.005x$

Number of mol of $I^- = \dfrac{0.4 \times 20}{1000} = 0.008$

Mol ratio of $Pb^{2+} : I^- = 0.005x : 0.008$

From the equation, 1 mol of Pb^{2+} reacts with 2 mol of I^-.

Relating the mol ratio from the equation to the mol ratio from the calculation,

$$\frac{0.005x}{0.008} = \frac{1}{2}$$

$$x = \frac{\frac{1}{2} \times 0.008}{0.005}$$

$$= 0.80$$

24 D The brown gas is nitrogen dioxide. The anion in salt *Z* is a nitrate ion, which decomposes upon heating to release nitrogen dioxide gas and oxygen gas. The brown ring test uses dilute sulphuric acid, iron(II) sulphate solution followed by concentrated sulphuric acid confirms the presence of nitrate ions.

25 A Sodium carbonates do not decompose when heated.

26 B An ammonium salt solution produces ammonia gas (which turns red litmus paper blue) when heated with an alkali (sodium hydroxide).

27 C PbO forms a brown solid when hot, and yellow when cold. A colourless gas that turns moist blue paper red and does not rekindle glowing wooden splint is CO_2.

28 B Zinc chloride solution forms a white precipitate, which is soluble in excess aqueous ammonia. Aluminium nitrate solution forms a white precipitate, which is insoluble in excess aqueous ammonia. Both solutions do not react with barium nitrate and barium chloride solutions and both form white precipitate that are soluble in excess sodium hydroxide.

29 C Chloride forms a white precipitate (AgCl) when it reacts with $AgNO_3$. Zinc nitrate is absent since the white precipitate is insoluble in excess aqueous ammonia.

30 D Only Pb^{2+} forms a white precipitate ($Pb(OH)_2$), which is soluble in excess sodium hydroxide but not soluble in excess ammonia. Zn^{2+} will form a white precipitate that is soluble in both solutions, while Mg^{2+} will form a white precipitate that is insoluble in both solutions. Ca^{2+} does not form white precipitate with aqueous ammonia.

/

Explanation for Multiple-choice Questions

FORM 4

SUMMATIVE PRACTICE 7

1 D Rusting takes days or even months to be noticeable. The other reactions are very fast.

2 A The rate of a chemical reaction can be measured as the change of concentration of a solution, the mass of a solid, or the volume of a gas produced per unit time in second or minute. Option **A** is the measurement for concentration.

3 C For reactions that involve the liberation of gases, the volume of gas liberated per unit time is the easiest to measure using a gas syringe or by the displacement of water method (for gases that are insoluble in water).

4 D The average rate of reaction during the second minute

$$= \frac{13.6 \times 7.8}{120 - 60}$$

$= 0.097\ cm^3\ s^{-1}$

The reaction is complete at 180 s, the average rate of reaction

$$= \frac{14.7}{180}$$

$= 0.8\ cm^3\ s^{-1}$

The initial and instantaneous rate of reaction need to be obtained from the gradient of the graph of volume of gas against time.

5 B 120 s = 2 min

The average rate of reaction $= \frac{0.2}{2}$

$= 0.10\ g\ min^{-1}$

or $\frac{100}{2} = 50\ cm^3\ min^{-1}$

6 B The total volume of gas produced is 24 cm^3 of gas and the reaction is completed in 240 s (4 min).

The overall average rate of reaction

$$= \frac{\text{total volume of gas}}{\text{total time taken}}$$

$$= \frac{24\ cm^3}{4\ min} = 6.0\ cm^3\ min^{-1}$$

7 B The reaction between magnesium and hydrochloric acid produces hydrogen gas as a product. The volume of hydrogen gas (product) increases with time as the reaction proceeds, therefore producing an increasing curve. The mass of magnesium (reactant) decreases with time as the reaction proceeds, hence resulting in a decreasing curve.

8 D The stopwatch reading shows that more time is required to form *q* grams of sulphur in experiment II, indicating the rate of reaction is lower than in experiment I.

Distilled water is added in option **D**, resulting in a lower concentration of reactant that causes a lower rate of reaction. Experiment II has a higher rate of reaction in option **A** (due to higher temperature) and in option **B** (due to the concentration of the reactant). The rate is the same in both experiments for option **C**.

9 D *Y* has a higher rate of reaction (steeper gradient) than *X* due to a higher concentration of H^+ ions. The concentration of H^+ ions in 1 mol dm^{-3} sulphuric acid is twice the amount in 1 mol dm^{-3} hydrochloric acid as sulphuric acid is a diprotic acid.

The total volume of gas produced in *Y* is the same as in *X* , hence the total number of mol of H^+ ions (calculated from $\frac{MV}{1000}$) is the same for both *X* and *Y*.

10 C The rate of a reaction decreases with time. (A is incorrect)

The volume of acid used does not affect the rate of the reaction. (B is incorrect)

Increasing the mass of zinc (increases the concentration of the reactant) increases the rate of reaction. (C is correct)

Increasing the size of zinc decreases the total surface area, and therefore decreasing the rate of reaction. (D is incorrect)

11 B Using hot hydrochloric acid increases the temperature of the reactants, which increases the rate of reaction. (B is correct)

Bigger sized marbles (decreases the total surface area of the reactant) as well as adding water (decreasing the concentration of the reactants) decreases the rate of reaction. (A and D are incorrect)

The volume of acid used does affect the rate of reaction. (C is incorrect)

12 B Increasing the size of magnesium ribbon decreases the total surface area of the reactant, therefore decreasing the rate of reaction.

13 B The total volume of hydrogen gas produced in experiments I and III is the same, as the number of moles of both reactants is the same. However, experiment III has a higher rate of reaction due to higher temperature, resulting in a steeper curve gradient. The volume of hydrogen gas produced in experiment II is the same as the number of moles of HCl $\left(\frac{50 \times 0.5}{1000}\right)$ used, which was less than in Experiments I and II, thus the curve is less steep due to the lower concentration of the acid used.

14 A Only the manufacture of sulphuric acid in the Contact process uses vanadium(V) oxide as a catalyst. The manufacture of ammonia uses iron, while nitric acid uses platinum. The manufacture of margarine uses nickel or platinum.

15 D In a pressure cooker, the temperature is higher due to higher pressure, causing the meat pieces to have higher kinetic energy. The meat pieces also collide faster due to higher temperature as well as collide more frequently under higher pressure.

16 B Explanation:
The balloon is bigger in experiment II, showing that more gas is produced in 5 minutes. Experiment II involves the use of copper(II) sulphate as a catalyst in the reaction between zinc and sulphuric acid. The presence of a catalyst lowers the activation energy of the reaction, resulting in more reactant particles having higher energy than the activation energy. A catalyst does not increase the energy or the number of reactant particles.

17 D Curve II has a steeper gradient (higher rate) but a smaller volume of gas is produced. When the same concentration of hydrogen peroxide at half the volume is used, the volume of gas produced is half, however, the number of effective collisions increases at higher temperatures.
Options **A** and **B** are wrong as using a catalyst (manganese oxide) and the higher temperature does not affect the total volume of oxygen gas produced. Option **C** is wrong as using half the volume but at twice the concentration of hydrogen peroxide results in the same number of moles of hydrogen peroxide, producing the same volume of oxygen gas.

18 C The frequency of collisions depends on the number of reactant particles per unit volume. The increase in the total number of reactant particles may not increase the rate of reaction if it is accompanied by an increase in the volume. The rate does not depend on the number of product particles.

19 B Activation energy is the difference in the energy level between the reactants and the maximum point of the energy profile.

20 C The kinetic energy of reactants increases when temperature increases, causing the reactant particles to collide more frequently, as well as having more reactant particles that have energy higher than the activated energy.

Explanation for Multiple-choice Questions

FORM 4

SUMMATIVE PRACTICE 8

1 A Brass consists of copper and zinc.
Bronze consists of copper and tin.
Cupronickel consists of copper and nickel.
Duralumin consists of aluminium, copper, magnesium and manganese.

2 D Only soda lime glass has a low melting point and is easily moulded.

3 D Foreign atoms occupy the empty spaces between metal atoms. They disrupt the regular arrangement of metal atoms and prevent the metal atoms from sliding easily, increasing the hardness of the metal.

4 B Foreign atoms make the arrangement of atoms less regular. This causes the metallic bonds between metal atoms to be weaker. Thus, alloys have lower melting point that pure metal.

5 A The main metal in duralumin is aluminium, Al, while in stainless steel, iron, Fe. The main metal in brass is copper, Cu, and in pewter is tin, Sn.
The relative atomic masses of the main metals are Al = 27, Fe = 56, Cu = 64, and Sn = 119.
An aeroplane's body frame must be manufactured of light and strong alloy.
Duralumin alloy fits the criteria.

6 A Pewter contains 97% tin and 3% antimony and copper.

7 A The alloy of copper and nickel is called cupronickel alloy. This alloy is shiny and does not corrode easily. It is suitable to be used to make coins.

8 A Solder is 50% tin and 50% lead.

9 C Glass is made from silica sand or silicon(IV) oxide.

10 D An aeroplane flies from sea level to a height of about 10 000 meter. The plane is exposed to extreme changes in temperature from an average of 25°C to –45°C. Normal glass will break due to this extreme changes in temperature. However, borosilicate glass has a low coefficient of expansion and can withstand extreme changes in temperature.

11 C Bottles come in different shapes. These bottles are made from soda lime glass, which has a low softening point of about 700°C, unlike fused glass, which has a softening point of 1700°C.
After heating soda lime glass to its softening point, the molten glass is blown into different shapes to make bottles, bulbs, etc.

12 C Boron trioxide in borosilicate glass lowers the coefficient of expansion.

13 B Lead metal sheets prevent the penetration of X-rays through it. Lead glass is made from silica and lead(II) bromide. The glass is transparent. However, the lead content in the glass absorbs high energy X-ray radiations.

14 B Silicon carbide is a very hard substance with the MOH value of 9. Diamond is the hardest substance. It has the MOH value of 10. Therefore, silicon carbide can be used to cut metals.

15 D A superconductor has no resistance to the flow of electricity. Yttrium copper oxide is a ceramic, which is a superconductor.

16 B Zirconia is produced from zirconia dioxide, which is a ceramic material.

17 C Glass fibres are hard but not flexible. Polyester plastics are soft and flexible and but have limited uses. By adding glass fibres to polyester plastics (called matrix), a composite material called fibre glass, which is strong and flexible is produced.

18 A Photochromic glass darkens according to light intensity. It consists of two materials that are glass and silver halide salt, which decomposes in sunlight to form silver atoms, hence darkening the glass.

19 A Ceramic is an electrical insulator. It is used as insulator in high tension wires.

20 B Besides being a good electrical insulator, ceramic is also a good heat insulator. It is used to shield astronauts inside space shuttles during their re-entry phase, during which the temperature can go up to 1500°C.

21 B Optical fibres consist of two glasses with different refractive indexes. Thus, light travelling in optical fibres undergoes total internal reflection, which enables surgeons to see the internal organs of patients.

22 D Silicon(IV) oxide is used to make glass. Glass is an electrical insulator.
Silicon is a semiconductor used to make diodes and transistors.
Aluminosilicate is white clay used to make traditional ceramics, such as plates and cups.
Molybdenum disilicide is a ceramic, which can conduct electricity, and is used to make the heating filaments in water heaters and electrical ovens.

23 A Tiles and bricks are made from wet clay, which after being heated in a furnace, hardens and ceramic is produced.
Beams in buildings are made from steel reinforced concrete which is a composite material.
Windowpanes are made from silica/silicon(IV) oxide.

24 C Photochromic glass contains silver halide salts. When exposed to sunlight, the compound decomposes to silver atoms and halogens. The silver atoms darken the glass.

25 C Modern badminton rackets are made from carbon fibres and polyester plastic composite. This material is light, strong and does not break easily.

26 B Racing bikes are used in races, so it must be light but hard.
Fibreglass is light but not hard enough for this purpose.
Manganese steel is made mainly from iron (RAM of Fe = 56). This material is hard but heavy.
Duralumin alloy is made mainly from aluminium (RAM of Al = 27). The alloy is hard and light, making it suitable to be used to make racing bikes.

27 D The telecommunication industry uses optical fibres to transmit light pulses along glass fibres. The data transmitted is in the form of light, unlike copper wire which uses electricity. Resistance in copper also slows down the speed of data transmission.
To transmit light through optical fibres without the light escaping, optical fibres consist of two glasses with two different refractive indexes. This enables a total internal reflection to occur.

28 B Glass fibres hold polyester polymer together, thus making it stronger and harder.

29 B Concrete contains cement, sand and gravel. Once hardened, it is hard but it cannot withstand tremors such as due to earthquake. To strengthen it, concrete steel rods are tied together before the concrete is poured into the column. Once hardened, steel reinforced concrete is obtained, which is a composite material. Steel has a high tensile strength and prevents beams from breaking easily during tremors.

30 A

31 B

32 D Yttrium copper oxide is a superconductor, but its use is limited because it is brittle and breaks easily. By combining it with a polymer, it becomes more flexible and more bendable.

33 C Wind turbine blades must be strong and light so that when strong winds rotate the blades, they do not break. Steel, duralumin and ceramic are heavy and not suitable to be used to make wind turbine blades. Fibre glass is not only strong but it is also light.

34 C The mirrors in telescopes are made from borosilicate glass because of its high softening point, low coefficient of thermal expansion and resistance to corrosive chemicals.

35 C Tooth composites contain ceramic and Perspex polymer. Once the material is applied to a tooth as a filling and exposed to ultraviolet light, the polymerisation process takes place. The polymer will harden together with the ceramic materials.

36 D All are made of fibre glass as it is strong, flexible and light.

Explanation for Multiple-choice Questions

FORM 5

SUMMATIVE PRACTICE 1

1 C $C + 2CuO \rightarrow CO_2 + 2Cu$
Carbon gains oxygen to form CO_2 and the oxidation number of carbon increases from 0 (in element C) to +4 (in CO_2).
Copper(II) oxide loses oxygen to form copper and copper(II) ions accept electrons (not copper).

2 B In Cl_2 is reduced and its oxidation number decreases from 0 to –1.

3 A In the reaction, I^- in KI is oxidised to I_2 by donating electrons and its oxidation number increases from –1 to 0. Br_2 is reduced to Br^- in KBr by accepting electrons and its oxidation number decreases from 0 to –1.

4 A The oxidation number of H decreased from +1 to 0, while Zn increased from 0 to +2 in **A**. The oxidation numbers of all species remained unchanged in **B**, **C** and **D**.

5 C Chlorine is an oxidising agent that oxidises Fe^{2+} ions (green) to Fe^{3+} ions (brown).
Potassium dichromate(VI) is also an oxidising agent. Potassium bromide and potassium iodide are reducing agents. Iron(III) sulphate does not react with Fe^{2+}.

6 C Chlorine, iodine and concentrated nitric acid are all oxidising agents. On the other hand, potassium iodide is a reducing agent.

7 D Let the oxidation number of Cl = x

$NaClO_4$

$+1 + x + 4(-2) = 0$

$x = +7$

8 C The oxidation number of sulphur, S, in both $Na_2\underline{S}O_3$ and $\underline{S}O_2$ is +4.
In option **A**, the oxidation number of chlorine, Cl, changes from –1 to +1.
In option **B**, the oxidation number of manganese, Mn changes from +7 to +6.
In option **D**, the oxidation number of chlorine, Cl, changes from –1 to +1.

9 B Let the oxidation number of Mn = x
In MnO_4^{2-}: $x + 4(-2) = -1$
$x = +7$
The oxidation number of Mn in MnO_4^{2-} is +7, the oxidation number of Mn in Mn^{2+} is +2

10 C Solution X is an oxidising agent that oxidises iodide ions to iodine, which is brown.
Potassium dichromate(VI) is an oxidising agent. Potassium bromide and potassium chloride are reducing agents.

11 B X has been oxidised (by Y^{2+}) to X^{2+} ions and Y^{2+} ions are reduced (by X) to Y in the reaction. Hence, X is a reducing agent, while Y^{2+} is an oxidising agent.
X is more electropositive than Y because X has a higher tendency to release electrons.

12 D Cu is oxidised to Cu^{2+} by donating electron to Ag^+. Cu is the reducing agent (electron donor) and Ag^+ is the oxidising agent (electron acceptor).

13 B Fe^{3+} ions are reduced to Fe^{2+} ions in the reaction; hence sodium sulphite is the reducing agent. Zinc metal is the suitable replacement as a reducing agent, while bromine water and Cu^{2+} ions from copper(II) sulphate the oxidising agents. Cl^- ions from potassium chloride, which cannot reduce Fe^{3+} ions they are below Fe^{3+} ions in the redox series (the E° value is more positive).

14 B In option **B**, $Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$.
Therefore, Cu is oxidised to Cu^{2+} ions.
In option **A**, $C + 2CuO \rightarrow CO_2 + 2Cu$.
Therefore, Cu^{2+} ions are reduced to Cu.
In option **C**, at the carbon cathode $Cu^{2+} + 2e^- \rightarrow Cu$. Therefore, Cu^{2+} ions are reduced to Cu.

15 D The decolourising of the blue colour indicates that Cu^{2+} ions are reduced by accepting electrons. $Cu^{2+} + 2e^- \rightarrow Cu$
The oxidation number of copper decreases from +2 to 0.
X is the reducing agent and Cu^{2+} ions (not Cu) undergo reduction.

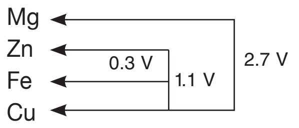
16 B N has a more negative E° value than M, indicating that N has a higher tendency to release electrons compared to M; hence metal N is the stronger reducing agent than M.
M has a more positive E° value, indicating the ions of M have a higher tendency to accept electrons than ions of N; hence N ions are stronger oxidising agents than M ions.

17 C When *P* and *Q* metal pairs are used to form a voltaic cell, reduction occurs at *P* as it has a more negative E° value (option **A** is wrong).
When *Q* and *R* metal pairs are used to form a voltaic cell, *Q* will be the anode as it has a more negative E° value (option **B** is wrong).
When *Q* and *S* metal pairs are used to form a voltaic cell, *Q* is the anode as it has a more negative E° value and cell voltage = $E°_{cathode}$ – $E°_{anode}$ = +0.34 V – (–1.66 V) = 2.00 V (option **C** is correct).
When *R* and *S* metal pairs are used to form a voltaic cell, reduction occurs at *S* as it has a more positive E° value. Hence S^{2+} ions accept electrons to form *S* metal (option **D** is wrong).

18 A The half-cell with a more negative E° value (Al) acts as the anode to release electrons. Al loses electrons and is oxidised to Al^{3+} ions, while Pb^{2+} ions gain electrons and are reduced to Pb. Oxidation is written on the left and reduction on the right in a cell notation.

19 B Oxidation occurs at the anode, whereby the metal with the smaller E° value, releases electrons, which flow to the cathode.

20 A The bigger the voltage reading, the further is the distance between the metals.



The voltmeter reading between magnesium and iron = (2.7 – 1.1) + 0.3 = 1.9 V

21 C Zinc acts as the negative terminal of the voltaic cell because it has a more negative E° value compared to copper, and releases electrons to form Zn^{2+} ions.
The positive ions, Zn^{2+}, K^+ and H^+ ions (from aqueous KCl) move to the anode.
H^+ ions accept electrons to form H_2 gas (E° values of Zn^{2+} and K^+ ions are negative, therefore they are less likely to accept electrons compared to H^+ ions).

22 D Electrolysis of dilute copper(II) chloride solution produces oxygen gas at the anode, whereas concentrated copper(II) chloride solution produces chlorine gas at the anode. The concentration of the other solutions does not affect the formation of products in electrolysis.

23 B Both cations, Mg^{2+} and H^+ ions, are attracted to the cathode, but only H^+ ions are discharged, producing hydrogen gas because of its higher E° value.

24 C The electrolysis of copper(II) sulphate produces copper metal at the cathode (factor: E° value). As for the rest of the solutions, H^+ ions and OH^- ions are discharged, producing hydrogen gas at the cathode and oxygen gas at the anode, repectively.

25 C If a concentrated potassium chloride solution is electrolysed, chloride ions are discharged at the anode, producing chlorine gas (factor: concentration of electrolyte). The other factors do not affect the selective discharge of ions during electrolysis.

26 B When an impure copper is used as the anode and aqueous copper(II) salt is used as the electrolyte, copper loses its electrons to form copper(II) ions at the anode (Factor: Active electrode).

27 C In electroplating, the metal to be plated (silver in this case) must be the anode, while the iron key must be the cathode. In the diagram, silver metal is connected to the negative terminal of the batteries forming the cathode, while iron key is connected to the positive terminal, the anode.

28 B Iron, which is less reactive than carbon, is extracted by reducing hematite using carbon. Aluminium, which is more reactive than carbon, is extracted by the electrolysis of molten bauxite. Copper ores, which consists of copper metal and a little amount of copper sulphide, is extracted by heating the ores in air.

29 C $3C + 2Fe_2O_3 \rightarrow 3CO_2 + 4Fe$
Carbon undergoes oxidation and iron(III) oxide is the oxidising agent. The oxidation number of iron decreases from +3 to 0, while O^{2-} ions remain unchanged.

30 C In the rusting process of iron, Fe metal loses electrons to form Fe^{2+} ions in oxidation. The part of iron labelled as *Z* is at the edge of the water droplet, which has a high concentration of oxygen gas, forming the anode. Oxygen and water receive electrons to form hydroxide ions in a reduction in rusting.

31 C Magnesium, zinc and aluminium are more electropositive than iron, while tin is less electropositive than iron (below iron in the electrochemical series). Hence, Fe has a higher tendency than Sn to lose electrons to produce Fe^{2+} ions in rusting. Fe^{2+} ions react with potassium hexacyanoferrate(III) to form blue colour.

Explanation for Multiple-choice Questions

FORM 5

SUMMATIVE PRACTICE 2

1 B Calcium carbonate, carbon monoxide and copper(II) oxide are inorganic compounds. Only glucose is an organic compound derived from living organisms.

2 C Alkenes have carbon-carbon double bonds and alkynes have carbon-carbon triple bonds. Both are unsaturated hydrocarbons.

3 C $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$
$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

4 A Propene and propane have 3 carbon atoms per molecule. Both produce 3 mol (3 volumes) of CO_2 in combustion reactions. However, propane produces more H_2O because it has more hydrogen atoms per molecule compared to propene. Propene produces more soot because of its higher percentage of carbon by mass compared to propane.

5 D Butyne, C_4H_6 has the highest percentage of carbon by mass. It produces the most soot (unburned carbon) in an incomplete combustion.

6 C The general formula of alkyne is C_nH_{2n-2}

7 B The longest carbon chain has 4 carbon atoms with a triple bond as the functional group in the first C atom and a methyl branch in the third C atom.

8 B 7.2 cm^3 of CO_2 and H_2O = $\frac{72}{24\ 000}$ = 0.0003 mol, respectively.
The number of moles of C = number of mol of CO_2, while the number of moles of H = 2 × the number of moles of H_2O
Hence, the mol ratio of C : H = 0.0003 : 0.0006
= 3 : 6

9 C *P* is methane, CH_4, an alkane that undergoes substitution reaction in the presence of sunlight.
C_3H_8 is propane, which is also an alkane, that can also undergo substitution reaction.

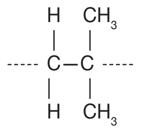
10 A A diol is formed when ethene is added to acidified potassium manganate(VII).
$C_2H_4 + H_2O + [O] \rightarrow C_2H_4(OH)_2$

11 D Butene, C_4H_8, is transformed to butane, C_4H_{10}, by adding hydrogen in hydrogenation.
$C_4H_8 + H_2 \rightarrow C_4H_{10}$

12 D Butene is an alkene, it undergoes addition reactions with steam, bromine and hydrogen gas. It does not react with hydrochloric acid but undergoes addition reaction with hydrogen chloride gas.

13 B Propene undergoes addition reaction with hydrogen chloride gas to produce 2-chloropropane.

14 D The repeating unit of the polymer is:



To obtain the structural formula of the monomer, change the single bond between the two carbon atoms to a double bond and then remove the two single bonds attached to the carbon atoms.

15 A The structural formula of *M* shows a carbon-carbon double bond (C=C), indicating *M* is an alkene. Alkenes undergo addition reactions with acidified potassium manganate(VII) to form diols, decolourising the potassium manganate(VII) in the process.

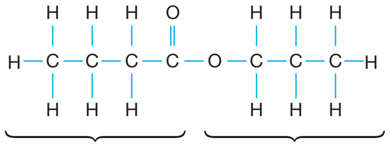
16 C Ethanol, C_2H_5OH, is oxidised to ethanoic acid, CH_3COOH, in oxidation reactions using an oxidising agent, such as acidified potassium dichromate(VI) or acidified potassium manganate(VII) while being heated.

17 C Compound *Q* is not an alkene as it did not result in an addition reaction with cold acidified potassium manganate(VII).
Compound *Q* is not propane as it is soluble in water and not propanoic acid as it cannot conduct electricity.
Compound *Q* is an alcohol that can be oxidised to a carboxylic acid when heated with acidified potassium manganate(VII).

18 C Methanol has only one carbon atom in a molecule. It cannot undergo dehydration to form an alkene. All alcohols can be oxidised to carboxylic acids in oxidation reactions and react with carboxylic acids (not alcohols) to form esters.

19 D Compound *Y* is a carboxylic acid as it produces carbon dioxide gas with sodium carbonate.

20 A The compound shown is an ester. The first part of the IUPAC name of an ester is derived from the alcohol part, while the second part comes from the acid in a carboxylic acid.



This comes from a carboxylic acid with 4C (butanoic acid). The second part of the ester's name is butanoate.	This comes from an alcohol with 3 C (propanol). The first part of the ester's name is propyl.

21 D The molecular formula shown is an ester formed by the reaction between an alcohol with 4 C atoms and a carboxylic acid with 3 C atoms.

$$C_2H_5COOC_4H_8$$

The carboxylic part with 3 C atoms is C_2H_5COOH

The alcohol part with 4 C atoms is C_4H_8OH

22 D *Q* is an ester formed from the reaction between a carboxylic acid and an alcohol.

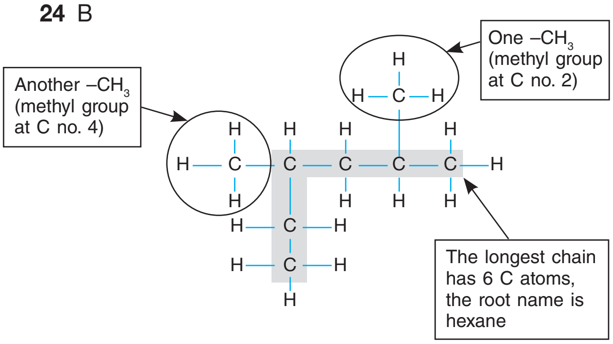
$$C_2H_5COOCH_3$$

From propanoic acid

From methanol

23 C Ethanol reacts with ethanoic acid to form an ester with a sweet smell.
Water flows in from *Q* and flows out from *P*.
The Liebig condenser is used to prevent evaporation of volatile reactants before the reaction completes.

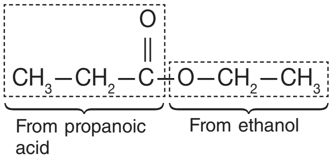
24 B



25 C Compound *Q* is an alkane with 5 C atoms and 12 H atoms (molecular formula C_5H_{12}).
The structural formula of the compound in option **C** also has the molecular formula C_5H_{12}.

26 B Compound *Z* is an alcohol since it reacts with ethanoic acid to form an ester (a sweet smelling compound).
Alcohol *Z* has a $-CH_3$ (methyl) group attached to the second C atom of the parent chain to form 2-methylpropene.
Alcohol in option **A** produces propene in dehydration.
Alcohol in option **C** produces but-1-ene in dehydration.

27 C



28 C Isomers must have the same number of atoms of elements. The molecular formula of C_4H_9OH shows that the compound has 4 C atoms, one O atom and one H atom, with -OH as the functional group. Options I, II and III all have 4 C atoms with the -OH group. Option IV has 5 C atoms.

29 D Structural isomers have different structural formulae but the same molecular formula, hence the same number of C and H atoms, producing the same number of mol of carbon dioxide and water on complete combustion. The functional groups may be the same or different, hence the chemical properties may differ if the functional group is different.

30 C Only 1-butanol and 2-methyl propanol have the same number of C, H and O atoms with the molecular formula of C_4H_9OH. The pairs in the other options have different molecular formulae.
Butane has 10 H atoms, while butene has 8 (**A** is wrong).
Butane has 4 C atoms, while 2-methyl butane has 5 (**C** is wrong).
2,2-dimethyl propane has 5 C atoms, while 2-methyl propane has 4 (**D** is wrong).

Explanation for Multiple-choice Questions

FORM 5

SUMMATIVE PRACTICE 3

1 A The positive ΔH indicates an endothermic reaction, which absorbs heat from the surroundings.

2 B The combustion of 1 mole of carbon produces 394 kJ of heat.

Therefore, $\frac{59.1 \text{ kJ}}{394 \text{ kJ mol}^{-1}}$
= 0.15 mol

The mass of carbon = 0.15 mol × 12 g mol^{-1}
= 1.8 g

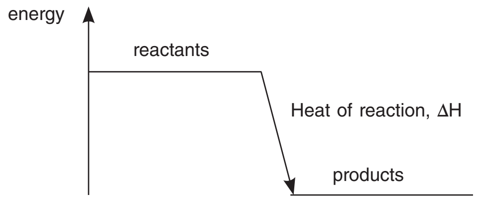
3 A The product of the reaction, *C*, has a lower energy content. Thus, the reaction is an exothermic reaction, where heat is released and the temperature of the surroundings increases. (I is true and IV is false)
The energy level diagram does not tell us whether a catalyst is used or not in the reaction. (II is false)
Breaking the bonds in reactants before they can react is an endothermic reaction, where heat is absorbed. Forming the bonds in products is an exothermic reaction where heat is released. As the reaction is exothermic, more energy is released during the formation of the bonds of the products than the energy absorbed to break the bonds of the reactants. (III is true)

4 C The energy profile does not tell us whether the reaction is reversible or not. (I is false)
The reaction is exothermic as the products have lower energy content. For exothermic reactions, the value of ΔH is negative. For this reaction, ΔH = – (T_2 – T_1). (II is true)
The reactants, *A* and *B*, must overcome (T_3 – T_2) kJ mol^{-1} before they can form product *C*. (III is true)

5 D The value of Δ*H* is positive. Thus, the reaction is endothermic, where heat is absorbed from the surroundings. The temperature of the surroundings decreases. (**A** is false)
Since energy is absorbed from the surroundings, the products have higher energy content than the reactants. (**B** is false)
The ΔH value = +18 kJ mol^{-1} is the heat of reaction, not the activation energy. (**C** is false)
More heat is absorbed to break the bonds of the reactants than the heat energy released during the formation of the bonds of the products. Thus, the overall ΔH value is positive. (**D** is true)

6 C Pb^{2+} + $2I^-$ → PbI_2 ΔH = negative
Reactants Product
Since the reaction is exothermic, the value of ΔH is negative.
The product, PbI_2, has lower energy content than the reactants.

7 A



8 B Reaction I is the decomposition of ammonium chloride to ammonia gas and hydrogen chloride gas. Before ammonium chloride could decompose, it must absorb energy from the surroundings. Reaction I is endothermic. (I is false)
The reactions between metals and acids release heat. The reaction is exothermic. (II is true)
Before copper(II) carbonate can decompose to copper(II) oxide, carbon dioxide and water, it must absorb heat from the surroundings. Reaction III is endothermic. (III is false)
All displacement reactions of metals from their salt solutions by more electropositive metals are exothermic reactions. (IV is true)

9 C The number of moles of reactants in 50 cm^3 0.1 mol dm^{-3}, $n = \frac{50 \times 0.1}{1000}$ = 0.001 mol
When 0.001 mol of $AgNO_3$ reacts with 0.001 mol of NaCl, the temperature increases by *t*°C.
The number of moles of reactants in 50 cm^3 0.2 mol dm^{-3}, $n = \frac{50 \times 0.2}{1000}$ = 0.002 mol

When 0.002 mol of $AgNO_3$ reacts with 0.002 mol of NaCl, the heat released is double the amount released in the first experiment. As the total volume of the solution used is the same for both experiments (100 cm^3), the temperature of the mixture in experiment II is $2t$°C.

10 A When 1 mole of lead(II) sulphate is produced, 50 kJ or 50 000 J of heat is released.
If 250 J of heat is released, the number of moles of lead(II) sulphate produced

$= \frac{250}{50\ 000} \times 1$ mol

= 0.005 mol

$Pb^{2+}(aq)$	+	$SO_4^{2-}(aq)$	→	$PbSO_4(s)$
0.005 mol		0.005 mol		0.005 mol

Number of moles, $n = \frac{MV}{1000}$, where

M = molarity of solution, V = volume of solution

$$0.005 = \frac{0.1V}{1000}$$

$$V = 50\ cm^3$$

11 C The number of moles of $MgCl_2$

= The number of moles of Na_2CO_3

$= \frac{100}{1000} \times 2$ mol

= 0.2 mol

When 1 mol of magnesium carbonate is formed, 12.6 kJ of heat is released.
If 0.2 mole of magnesium carbonate is formed, the heat released is

0.2×12.6 kJ = 2.52 kJ

= 2520 J

When the solutions are added, the total volume of the mixture is 200 cm^3.

Heat, $H = m \times c \times \theta$

$2520 = 200 \times 4.2 \times \theta$, $\theta = 3$°C

12 B Experiment A: Excess NaCl (25 cm^3)
Experiment B: Excess $AgNO_3$ (5 cm^3)
Experiment C: Excess NaCl (10 cm^3)
Experiment D: Excess $AgNO_3$ (10 cm^3)
Excess solution will absorb the heat released during a reaction and causes the temperature to increase less. In experiment B, the excess solution is only 5 cm^3. Thus, the mixture will show the highest rise in temperature.

13 C Heat released during the experiment, $H = mc\theta$, where $m = 50 + 50 = 100\ cm^3$, $\theta = 3$°C

$H = 100 \times 4.2 \times 3$ J

= 1260 J

= 1.26 kJ

Given that $\Delta H = -50.4\ kJ\ mol^{-1}$

When 1 mole of lead(II) sulphate is produced, 50.4 kJ of heat is released.
If 1.26 kJ of heat is released, the number of moles of lead(II) sulphate produced

$= \frac{1.26\ kJ}{50.4\ kJ} \times 1$ mol

= 0.025 mol

$Pb^{2+}(aq)$	+	$SO_4^{2-}(aq)$	→	$PbSO_4(s)$
0.025 mol		0.025 mol		0.025 mol

Number of moles, $n = \frac{MV}{1000}$, where

M = molarity of solution, $V = 50\ cm^3$

$0.025 = \frac{M \times 50}{1000}$

$M = 0.5\ mol\ dm^{-3}$

14 D The number of moles of reactant used,

$n = \frac{MV}{1000}$, where $M = 2\ mol\ dm^{-3}$, $V = 25\ cm^3$

$n = \frac{2 \times 25}{1000}$ mol

= 0.05 mol

Given that $\Delta H = -59\ kJ\ mol^{-1}$

When 1 mole of reactants reacts, 59 kJ of heat is released.
Thus, if 0.05 mole of reactants is reacted, the heat released = 0.05×59 kJ

= 2.95 kJ

= 2950 J

Heat, $H = mc\theta$, where $m = 25 + 25 = 50\ cm^3$

$2950 = 50 \times 4.2 \times \theta$

$\theta = \frac{2950}{50 \times 4.2}$

= 14°C

15 B Bromide ions are the limiting reactant. Therefore, the heat released depends on the amount of limiting reactant used. From the equation, 2 moles of bromide ions react to release X kJ of heat. Thus, 1 mol of bromide ions reacts to produce 0.5 X kJ of heat.

16 A Number of moles of copper(II) sulphate,

$n = \frac{MV}{1000}$, where $M = 0.1\ mol\ dm^{-3}$, $V = 50\ cm^3$

$n = \frac{0.1 \times 50}{1000}$ mol

= 0.005 mol

Given that $\Delta H = -210\ kJ\ mol^{-1}$

When 1 mole of copper(II) sulphate reacts, 210 kJ of heat is released.
Thus, if 0.005 mole of copper(II) sulphate is reacted, the heat released

$= 0.005 \times 210$ kJ

= 1.05 kJ
= 1050 J
Heat, $H = mc\theta$, where m = 50 cm^3, H = 1050 J
$1050 = 50 \times 4.2 \times \theta$
$\theta = 5°C$

17 B Heat, $H = mc\theta$, where m = 50 cm^3,
$\theta = 32.0 - 28.0°C = 4.0°C$
$H = 50 \times 4.2 \times 4$ J
= 840 J
= 0.84 kJ
The number of moles of Y sulphate,
$n = \frac{MV}{1000}$, where M = 0.2 mol dm^{-3}, V = 50 cm^3
$n = \frac{0.2 \times 50}{1000}$ mol
= 0.01 mol
When 0.01 mol of metal Y is displaced, 0.84 kJ of heat is released.
If 1 mole of metal Y is displaced, the heat released $= \frac{1}{0.01} \times 0.84$ kJ
= 84 kJ
$\Delta H = -84$ kJ mol^{-1}

18 C Heat released during the experiment, $H = mc\theta$, where m = 50 cm^3, $\theta = 6.2°C$
$H = 50 \times 4.2 \times 5.2$ J
= 1302 J
= 1.302 kJ
Given that $\Delta H = -104.16$ kJ mol^{-1}
When 1 mole of copper is displaced by tin, 104.16 kJ of heat is released.
If 1.302 kJ of heat is released, the number of moles of copper displaced
$= \frac{1.302}{104.16} \times 1$ mol
= 0.0125 mol

The number of moles of copper nitrate,
$n = \frac{MV}{1000}$, where M = molarity of solution,
V = 50 cm^3
n = 0.0125 mol
$0.0125 = \frac{M \times 50}{1000}$
M = 0.25 mol dm^{-3}

19 A The number of moles of copper(II) sulphate used in the reaction, $n = \frac{50}{1000} \times 0.5$
= 0.025 mole
When 1 mole of copper is displaced, 168 kJ of heat is released.
If 0.025 mole of copper is displaced, the heat released is
0.025×168 kJ = 4.2 kJ
= 4200 J
Heat, $H = m \times c \times \theta$
$4200 = 50 \times 4.2 \times \theta$
$\theta = 20°C$

20 D I $P + R$ nitrate $\rightarrow R + P$ nitrate
[Metal P is more reactive than R]
II $Q + R$ nitrate $\rightarrow R + Q$ nitrate
[Metal Q is more reactive than R]
III $P + Q$ nitrate $\rightarrow$ No reaction
[Metal Q is more reactive than P]
IV $S + R$ nitrate $\rightarrow$ No reaction
[Metal R is more reactive than S]
From equations I and II, we can conclude that metal P and Q are above metal R in the electrochemical series as they can displace metal R from its salt solution.
From equation III, we can conclude that metal P is below metal Q in the electrochemical series as it cannot displace metal Q from its salt solution.
From equation IV, we can conclude that metal S is below metal R in the electrochemical series as it cannot displace metal R from its salt solution. Therefore,

More electropositive Q
P
R
Less electropositive S

The further apart the metals in the electrochemical series, the higher the heat of displacement. The distance between metal Q and S is the furthest.
Thus, adding 1 g of metal Q to S nitrate solution will produce the highest increase in temperature.

21 D I $W + X$ nitrate $\rightarrow X + W$ nitrate ΔH_1
II $W + Y$ nitrate $\rightarrow Y + W$ nitrate ΔH_2
III $X + Y$ nitrate $\rightarrow Y + X$ nitrate ΔH_3
IV $X + Z$ nitrate $\rightarrow Z + X$ nitrate ΔH_4
The further two metals in the electrochemical series, the higher the heat of reaction.
Given $\Delta H_2 > \Delta H_1 > \Delta H_4 > \Delta H_3$
From equations I and II, metal W can displace metals X and Y from their salt solutions. This shows that metal W is above metals X and Y is the electrochemical series.
The value of ΔH_2 is higher than ΔH_1. Thus, the distance between metals W and Y is further than the distance between metals W and X.
From equations III and IV, metal X can displace metals Y and Z from their salt solutions.

This means that metal X is above metals Y and Z in the electrochemical series.
Given $\Delta H_4 > \Delta H_3$. This means that the distance between metals X and Z is further than distance between metal X and Y.

More electropositive W
X — Decreasing order
Y — of reactivity
Less electropositive Z ↓

Thus, the decreasing order of reactivity is W, X, Y, Z

22 A Given $\Delta H = -210 \text{ kJ mol}^{-1}$
When 1 mole of copper (64 g) is displaced, 210 kJ of heat is released.
Thus, if 0.64 g of copper is displaced, the heat released $= \frac{0.64}{64} \times 210$ kJ heat
$= 2.10$ kJ
$= 2100$ J
Heat, $H = mc\theta$, where $\theta = 25°C$
$2100 = m \times 4.2 \times 25$
$m = 20$ g
As the density of the solution is 1 g cm^{-3}, the volume of the solution is 20 cm^3.

23 B The maximum temperature is attained when all hydrogen ions neutralise hydroxide ions. This happens when 25 ml of acid is added to 25 ml alkali solution. The addition of excess acid solution until a total of 50 ml is added will cause the temperature to drop as water in the acid solution will absorb the heat produced during neutralisation.

24 C The heat of neutralisation between a weak acid and a weak alkali is the lowest. Ethanoic acid is a weak acid and ammonia is a weak alkali.

25 B The number of moles of methanoic acid or sodium hydroxide used, $n = \frac{MV}{1000}$, where
$M = 2.0 \text{ mol dm}^{-3}$ and $V = 50 \text{ cm}^3$
$n = \frac{2 \times 50}{1000}$
$= 0.1$ mole
Given that $\Delta H = -52.5 \text{ kJ mol}^{-1}$.
When 1 mole of acid reacts with 1 mole of alkali, 52.5 kJ of heat is released.
Thus, if 0.1 mole of acid reacts with 0.1 mole of alkali, the heat released
$= 0.1 \times 52.5$ kJ
$= 5.25$ kJ
$= 5250$ J
Heat, $H = mc\theta$, where $m = (50 + 50) \text{ cm}^3$
$5250 = 100 \times 4.2 \times \theta$
$\theta = 12.5°C$

26 A Heat released during the experiment, $H = mc\theta$, where $m = (25 + 25) \text{ cm}^3$, $\theta = 3.4°C$
$H = 50 \times 4.2 \times 3.4$ J
$= 714$ J
$= 0.714$ kJ
Given that $\Delta H = -57.12 \text{ kJ mol}^{-1}$.
When 1 mole of water is produced, 57.12 kJ of heat is released.
Thus, if 0.714 kJ of heat is released, the number of moles of water produced
$= \frac{0.741}{57.12}$ mol
$= 0.0125$ mol
Number of moles, $n = \frac{MV}{1000}$, where
$n = 0.0125$ mole, $V = 25 \text{ cm}^3$, M = molarity of solution
$0.0125 = \frac{M \times 25}{1000}$
$M = 0.5 \text{ mol dm}^{-3}$

27 C The number of moles of acid or alkali reacted is $\frac{11.34}{56.7} \times 1 \text{ mol} = 0.2 \text{ mol}$
The number of moles, $n = \frac{MV}{1000}$, where
$M = 2 \text{ mol dm}^{-3}$
$0.2 = \frac{2V}{1000}$
$V = 100 \text{ cm}^3$

28 D Ethanoic acid, CH_3COOH, is a weak acid. It dissociates partially in water to produce low concentrations of hydrogen ions. Heat energy is needed to ionise the acid molecules (not dissociated) before the hydrogen ions can be neutralised.
Thus, the heat of neutralisation between a weak acid and an alkali is lower.

29 D The RMM of $C_6H_{12}O_6 = 180$
The heat released from the combustion of 5.6 g of glucose,
$H = 500 \times 4.2 \times 32$ J
$= 67200$ J
$= 67.2$ kJ
When 1 mole of glucose (180 g) is burned, the heat released is
$H = \frac{180}{5.6} \times 67.2$ kJ
$= 2160$ kJ

30 C Given $\Delta H = -735 \text{ kJ mol}^{-1}$

When 1 mole of methanol, CH_3OH (32 g) is burned, 735 kJ of heat is released.
Thus, if 0.64 g of methanol is burned, the heat released $= \frac{0.64 \text{ g}}{32 \text{ g}} \times 735$ kJ
$= 14.7$ kJ
$= 14\,700$ J
Heat, $H = mc\theta$ where m = volume of water heated, $\theta = (42 - 28) = 14°C$
$14\,700 = m \times 4.2 \times 14$
$= 250 \text{ cm}^3$

31 B Heat released during the experiment, $H = mc\theta$, where $m = 1 \text{ dm}^3$ or 1000 cm^3, $\theta = (46 - 30)$
$= 16°C$
$H = 1000 \times 4.2 \times 16$
$= 67\,200$ J
$= 67.2$ kJ
Given ΔH = –8400 kJ mol^{-1}
When 1 mole of heptane, C_7H_{16} is burned, 8400 kJ of heat is released.
When 100 g of C_7H_{16} is burned, 8400 kJ of heat is released.
Thus, 67.2 kJ of heat is released from the combustion of $= \frac{67.2 \text{ kJ}}{8400 \text{ kJ}} \times 100$ g
$= 0.8$ g of C_7H_{16}

32 A Heat released during the experiment, $H = mc\theta$, where $m = 500 \text{ cm}^3$, $\theta = 37°C$
$H = 500 \times 4.2 \times 37$ J
$= 77\,700$ J
$= 77.7$ kJ
Combustion of 1.5 g of fuel released 77.7 kJ of heat.
Given $\Delta H = -1554 \text{ kJ mol}^{-1}$
When 1 mole of fuel R is burned, 1554 kJ of heat is released.
The mass of fuel needed to be burned to release 1554 kJ of heat $= \frac{1\,554 \text{ kJ}}{77.7 \text{ kJ}} \times 1.5$ g
$= 30$ g
Relative molecular mass of fuel R is 30.

33 C The number of moles of fuel burned
$= \frac{0.8}{40} = 0.02$ mol
The combustion of 0.02 mole of fuel X will release 0.02×273 kJ heat
$= 5.46$ kJ
$= 5460$ J
Assuming the rise in temperature is θ,
$H = m \times c \times \theta$
$5460 = 100 \times 4.2 \times \theta$
$\theta = 13°C$

34 D Given $\Delta H = -x \text{ kJ mol}^{-1}$
When 1 mole of fuel is burned, x kJ of heat is released.
If $0.025x$ kJ of heat is released, the number of moles of the fuel burned
$= \frac{0.025x}{x} \times 1 \text{ mol} = 0.025$ mol
From the equation, the combustion of 1 mole of toluene produces 7 moles of CO_2.
Therefore, the combustion of 1 mole of toluene produces
$7 \times 24 \text{ dm}^3$ of CO_2 at room conditions.
Thus, if 0.025 mole of toluene is burned, the volume of carbon dioxide produced is
$0.025 \times 7 \times 24 \text{ dm}^3 = 4.2 \text{ dm}^3$

35 A The alcohols listed are methanol, CH_3OH, ethanol, C_2H_5OH, propanol, C_3H_7OH, and butanol, C_4H_9OH.
Each alcohol has one oxygen atom. However, from one alcohol to the next consecutive alcohol, there is an increase of one carbon atom and two hydrogen atoms.

36 B

Fuel	C_2H_5OH	C_4H_{10}	CH_3OH	C_7H_{16}
RMM	46	58	32	100

Fuel value is defined as the heat released when 1 gram of fuel is burned.
Given heat of combustion of ethanol, ΔH is –1380 kJ mol^{-1}
When 1 mole of ethanol (46 g) is burned, 1380 kJ of heat is released.
If 1 gram of ethanol is burned, the heat released is $\frac{1}{46} \times 1380 \text{ kJ} = 30$ kJ
Given heat of combustion of butane, ΔH is –2968 kJ mol^{-1}
When 1 mole of butane (58 g) is burned, 2968 kJ of heat is released.
If 1 gram of butane is burned, the heat released is $\frac{1}{58} \times 2968 \text{ kJ} = 51.17$ kJ
Given heat of combustion of methanol, ΔH is –890 kJ mol^{-1}

When 1 mole of methanol (32 g) is burned, 890 kJ of heat is released.
If 1 gram of methanol is burned, the heat released is $\frac{1}{32} \times 890 \text{ kJ} = 27.81$ kJ
Given heat of combustion of heptane, ΔH is –4818 kJ mol^{-1}
When 1 mole of heptane (100 g) is burned, 4818 kJ of heat is released.

If 1 gram of heptane is burned, the heat released is $\frac{1}{100} \times 4818$ kJ = 48.18 kJ

37 C The most cost effective fuel is the fuel that is the least expensive for every kJ of heat released when it is burned.

Fuel	*W*	*X*	*Y*	*Z*
Heat of combustion, kJ g^{-1}	90	10	50	30
Cost per gram, cent g^{-1}	12	2	4	3
Cost per kJ of heat released, cent kJ^{-1}	0.133	0.2	0.08	0.1

Fuel *W*

$$\text{Cost per kJ of heat} = \frac{12 \text{ cent/g}}{90 \text{ kJ/g}} = \frac{12 \text{ cent}}{90 \cancel{g}} \times \frac{\cancel{g}}{\text{kJ}} = 0.133 \text{ cent kJ}^{-1}$$

Fuel *X*

$$\text{Cost per kJ of heat} = \frac{2 \text{ cent/g}}{10 \text{ kJ/g}} = 0.2 \text{ cent kJ}^{-1}$$

Fuel *Y*

$$\text{Cost per kJ of heat} = \frac{4 \text{ cent/g}}{50 \text{ kJ/g}} = 0.08 \text{ cent kJ}^{-1}$$

Fuel *Z*

$$\text{Cost per kJ of heat} = \frac{3 \text{ cent/g}}{30 \text{ kJ/g}} = 0.1 \text{ cent kJ}^{-1}$$

38 A Coal produces smog due to incomplete combustion.

39 A Fuel value is the heat released when 1 gram of fuel is burned.

Fuel	CH_4	C_6H_6	CH_3OH	C_2H_5OH
RMM	16	78	32	46
ΔH (kJ mol^{-1})	880	3264	890	1280
Fuel value	$\frac{180}{16}$ = 55 kJ g^{-1}	$\frac{3264}{78}$ = 41.84 kJ g^{-1}	$\frac{890}{32}$ = 27.81 kJ g^{-1}	$\frac{1280}{46}$ = 27.83 kJ g^{-1}

Explanation for Multiple-choice Questions

FORM 5

SUMMATIVE PRACTICE 4

1 D In saponification, concentrated sulphuric acid is reacted with concentrated sodium hydroxide.
2 C Treatment cosmetics are used to treat the body, which include skin moisturisers and facial masks.
3 D Both *J* and *K* have the same empirical formula.
4 C Neoprene is a synthetic rubber.
5 A The monomer of starch is glucose.
6 D Plastics release poisonous gas when burned.
7 C *Y* is polyvinyl chloride.
8 B
9 B
10 A
11 D Polymer *X* is a condensation polymer.
12 C Poly(2-methylbut-1,3-diene) is natural rubber.
13 D Latex contains polymer of natural rubber.
14 A Coagulation of latex can be prevented by adding alkaline solutions, such as aqueous ammonia.
15 B Coagulation speeds up when an acid is added to latex.
16 C
17 C Vulcanised rubber is harder and more resistant to oxidation and heat than unvulcanised rubber.
18 D Neoprene and styrene-butadiene rubber are examples of synthetic rubber.
19 A SBR only contains carbon and hydrogen. It is produced when styrene and but-1,3-diene monomers undergo addition polymerisation.
20 B

Explanation for Multiple-choice Questions

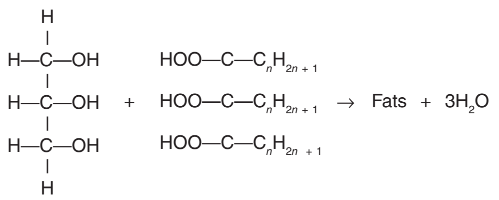
FORM 5

SUMMATIVE PRACTICE 5

1 D Saturated fats satisfy the formula C_nH_{2n+1}. Unsaturated fats do not satisfy the formula C_nH_{2n+1}.

Fat	I	II	III	IV
Hydrocarbon chain	$-C_{13}H_{27}$	$-C_{16}H_{31}$	$-C_{17}H_{35}$	$-C_{12}H_{23}$
General formula C_nH_{2n+1}	Satisfy	Does not satisfy	Satisfy	Does not satisfy
Conclusion	Saturated	Unsaturated	Saturated	Unsaturated

2 D Fats are made up of one glycerol and three fatty acid molecules.



3 C To make margarine, hydrogen gas is bubbled into an unsaturated plant oil in the presence of nickel as the catalyst. Hydrogen is added to the C = C double bonds to produce saturated fat.
The process of adding hydrogen to the C = C double bond is called hydrogenation.

4 A Glycerol is an alcohol. It contains the –OH group.
Sodium stearate, $C_{17}C_{35}COO^-Na^+$, is a salt of fatty acid.
Glyceryl tripalmitate is a natural ester produced in plants from esterification of one glycerol and three palmitic acid molecules.

5 B To produce soap, concentrated palm oil is boiled with sodium hydroxide. Sodium chloride solution is then added to precipitate the salt.

6 C Calcium ions and magnesium ions will react with soap to produce insoluble salts called scum.
$2RCOO^-(aq) + Ca^{2+}(aq) \rightarrow (RCOO)_2Ca(s)$ Scum
$2RCOO^-(aq) + Mg^{2+}(aq) \rightarrow (RCOO)_2Mg(s)$ Scum

7 B Soaps do not form lather in hard water because they form scum with the Ca^{2+} or Mg^{2+} ions present in hard water.
$2RCOO^-(aq) + Ca^{2+}(aq) \rightarrow (RCOO)_2Ca(s)$ Scum
$2RCOO^-(aq) + Mg^{2+}(aq) \rightarrow (RCOO)_2Mg(s)$ Scum
(**A** is false)
All soaps are biodegradable because their hydrocarbon chains consist of hydrogen atoms bonded to carbon atoms. Enzymes from the microorganisms present in the water can penetrate the hydrocarbon chains and break the chains. (**B** is true)
Soaps are ineffective in acidic solutions because they react with hydrogen ions to form insoluble fatty acids.
$RCOO^-(aq) + H^+(aq) \rightarrow RCOOH(s)$
Insoluble fatty acid
(**C** is false)
To make soaps, sodium chloride is added to precipitate out the soaps. (**D** is false)

8 C Step I involves incorporating sulphuric acid molecules into the hydrocarbon. The process is called sulphonation.
Step II involves neutralising another hydrogen ion from the sulphuric acid with sodium hydroxide.

9 A Both soap and detergent consist of hydrophobic hydrocarbon chains (C_nH_{2n+1}), which dissolve in grease. (**A** is true)

Soap	Detergent
$C_nH_{2n+1}COO^-$	$C_nH_{2n+1}OSO_3^-$
Alkyl carboxylate	Alkyl sulphate

Soap is an alkyl carboxylate salt whereas detergent is an alkyl sulphate salt. (**B** is false)
Soaps form scum in hard water whereas detergents do not. (**C** is false)
Soaps are ineffective in acidic water whereas detergents are effective in acidic water.
(**D** is false)

10 B Hydrophilic section of soap is carboxyl group $-COO^-$, whereas for detergent, it is the sulphate, $-OSO_3^-$, or sulphonate group, $-SO_3^-$.

11 A Sodium benzoate, C_6H_5COONa, and potassium nitrite, KNO_2, are food preservatives. (I and III are correct)
Pectin is a thickening agent added to jams. (II is incorrect)
Lecithin is an emulsifier to prevent oil and water from separating out. (IV is incorrect)

12 D Ascorbic acid is an antioxidant, aspartame is an artificial sweetener and monosodium glutamate is a food enhancer.

13 D Different food colour dye move at different speeds along a chromatography paper.
So this process can be used to separate the dyes.

14 C Ascorbic acid is an antioxidant, sodium benzoate is a food preservative, and lecithin is an emulsifying agent.

15 D Ringworm is caused by fungal infection. Thus, we apply antifungal lotions to treat it.

16 C Aspirin contains the functional group –COOH. This functional group ionises to produce H^+ ions, making the medicine acidic. The intestinal walls in children are thin and the acid can cause the intestinal walls to bleed.

17 D

18 A Disinfectants are a group of antimicrobials used to kill germs on non-living surfaces, such as surgical instruments and hospital floors.
Antiseptics are used to kill germs on living surfaces, such as skin.
Antibiotics are used to kill specific bacteria and it is usually taken orally.
Antivirals are used to kill specific viruses and it is usually taken orally.

19 A Rejuvenating cosmetics are cosmetics that make skin look healthier. Toners, serums and sunscreens are all rejuvenating cosmetics.

20 B Fragrances are volatile organic esters. It vapourises easily. If inhaled in excess, it may cause injury to lung tissues.

21 D Carbon has 4 valence electrons. In carbon nanotubes, three electrons of each carbon atom is used to form bonds, while one electron is highly mobile and can conduct electricity.
Thus, electrical cables coated with carbon nanotubes are better electrical conductors and have lower resistance.

22 B Wind turbine blades are made from the composite of carbon nanotubes (RAM of carbon = 12) and epoxy is lighter than those made from the composite of glass fibre (silicon dioxide, RMM = 60) and epoxy.

23 A Nano-sized pesticides are smaller compared to conventional pesticides. They penetrate through the skin of pests more easily.
Since they can penetrate faster, we need to spray less pesticide, reducing pesticide residue on food.
As less pesticide is sprayed, the amount of pesticides that leech through the ground and contaminate ground waters is also reduced.

24 C Clay produces ceramics when heated. Ceramic has a high melting point.
Firemen's uniforms have these ceramic particles to protect their skin from burning when putting out fires that are very hot.

25 A Nano-sized particles can be used to deliver drugs to specific cells, such as cancer cells, hence reducing damage to healthy cells.
Vitamins that are enclosed in nano-sized particles do not degenerate quickly as they are not exposed to air and microorganisms. As they are nano-sized, they can be absorbed by the body more efficiently.

26 D Nanosensors can detect small amounts of molecules present in the exhaled breaths of patients.

Compound detected	Disease
Acetone	Diabetes
Hydrogen sulphide	Halitosis (Bad breath) / Oral disease
Ammonia	Kidney malfunction
Toluene	Lung cancer

27 B Electrolysis can remove heavy metal ions from wastewater.
For example, chromium(III) ions in wastewater will move to the cathode and discharge.
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$
Another method is to pass the wastewater through a series of biofilms that contain microorganisms that can remove the heavy metal ions.

28 C Green Technology is the technology that reduces the negative impacts of human activities on the environment, such as water and land pollution as well as global warming.
It also uses renewable energies like solar, wind and wave energy to produce electricity.
Green Technology may also be in the form of repairing the damages already done to the environment.