EPH

N(A) LEVEL TOPICAL SCIENCE (CHEMISTRY) ANSWERS (2011–2020)

Must-Know Concepts INCLUDED Questions Analysis

TOPIC 1 Experimental Design, Methods of Purification and Analysis and Identification of Gases

Paper 3

1. **B**
X is a simple distillation process used to separate a pure solvent from a solution of a solute.
Y is a chromatography process used to separate and identify mixtures of small amounts of substances.
Z is a filtration process used to separate an insoluble solid from a liquid.

Must-Know Concept:
Identify apparatus that are specific for particular methods of separation.

2. **C**
A burette can measure the volume of a liquid up to 50 cm^3 with an accuracy of 0.1 cm^3. Hence, it can be used to measure 13.2 cm^3 of acid. A pipette can be used to measure fixed volumes of liquid (mostly 10.0 cm^3, 25.0 cm^3, 50.0 cm^3). Hence, it can be used to measure 25.0 cm^3 of alkali.

Must-Know Concept:
Note the different accuracies of different apparatus.

3. **B**
Distillation is used to obtain a pure solvent from a solution, such as the distillation of sea water to obtain pure water.

Must-Know Concept:
Simple distillation is the most suitable method to separate salt from sea water.

4. **A**
The boiling point of water is 100°C. Liquid X has a lower boiling point than that of water, thus options C and D are not correct. Since there are 20 intervals between the two main graduations, the scale increment is most likely to be 0.5°C. The reading is above the middle value of the two main graduations, so only option A is a possible answer.

Must-Know Concept:
Know the boiling point of water.

5. **D**
The diagram is an experimental set-up for fractional distillation. During fractional distillation of two liquids, the liquid with the lower boiling point will boil and be distilled first. The vapours of the liquid with the higher boiling point will condense along the fractionating column and fall back into the round-bottomed flask. Therefore, the initial composition of X will only contain T as it has a lower boiling point than S.

Must-Know Concept:
Relate the physical properties of chemicals to the method of separation.

6. **C**
X is a burette. It is a long, tube-like instrument with graduated markings in 0.1 cm^3 intervals and it has a clip at the end to control the liquid flowing out. Y is a balance. It measures the mass of substances.

Must-Know Concept:
Identify the apparatus used to measure volume and mass of liquid.

7. **B**

The chromatogram shows that all three sweets contain red dyes. On the chromatogram, spots that are in the same position horizontally are from the same substance. The spot of red dye in sweet **X** and the first spot of red dye in sweet **Z** are from one type of red dye. The spot of red dye in sweet **Y** and the second (higher) spot of red dye in sweet **Z** are from another type of red dye. Therefore, there are a total of two different types of red dyes present.

Must-Know Concept:
Spots which travel the same distance on a chromatogram indicate the same type of dye.

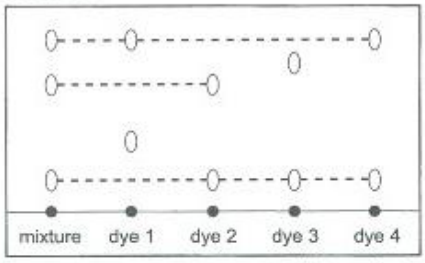
8. **A**

Oxygen is a gas that supports burning. The presence of oxygen causes a glowing splint to be relighted. Limewater is a test for the presence of carbon dioxide. Red litmus paper is a test for the presence of alkaline gases such as ammonia. A lighted splint is used to test for the presence of hydrogen.

Must-Know Concept:
Recall gas identification tests. Oxygen is a neutral gas.

9. **C**

On the chromatogram, spots that are in the same position horizontally are from the same substance.



The mixture contains spots which are in the same positions horizontally as the spots in dyes 2 and 4.

Must-Know Concept:
Note the distances travelled by each spot.

10. **B**

Chromatography is a separation technique that works based on the different solubilities of the substances tested. The more soluble a substance is in the solvent, the further it will travel up the chromatography paper.

Must-Know Concept:
Chromatography separates small amounts of two or more components that dissolve in the same solvent.

11. **A**

The melting point of option (A) and option (B) is above 20°C. Hence they will be in solid state at 20°C. Option (A) is pure as it has a fixed melting point.

Must-Know Concept:
Deduction from the given melting points the identities of substances and their purity

12. **B**

A burette accurately measures the volume of a liquid to the nearest 0.05 cm^3 with scale marked in 0.1 cm^3 division. A pipette accurately measures fixed volumes of liquids such as 20.0 cm^3 or 25.0 cm^3. A measuring cylinder measures volume of a liquid to the nearest 0.5 cm^3.

Must-Know Concept:
How to identify appropriate apparatus for the measurement of volume

13. **B**

Q is a burette. A burette is a long, tube-like instrument with graduated markings in 0.1 cm^3 intervals. It is positioned vertically using a retort stand, and has a clip or tap at the lower end to control the volume of the liquid flowing out of the burette. R is a balance (electronic balance) which is used to measure the mass of substances.

Must-Know Concept:
Identification of apparatus used to measure mass and volume of liquids

14. **A**

Most substances and their purity can be identified, given their fixed melting and boiling points. A solid is pure if it has a fixed melting point. A liquid is pure if it has a fixed boiling point.

Must-Know Concept:
Crystallisation - a separation technique used to obtain a pure solid sample from its solution

15. **D**
Sand (insoluble particles) can be separated from a mixture of sand and water (liquid) by filtration. The resulting residue is the sand while the filtrate is the water. In the crystallisation method, the salt solution is heated until most of the water has evaporated and this results in a hot saturated solution. When the hot saturated solution is allowed to cool, the dissolved solid will form as pure crystals. Simple distillation can be used to separate water (pure solvent) from the salt solution.

Must-Know Concept:
Filtration – to separate insoluble particles from a liquid; crystallisation – to obtain a pure solid sample from its solution; simple distillation – to separate a pure solvent (liquid) from a solution

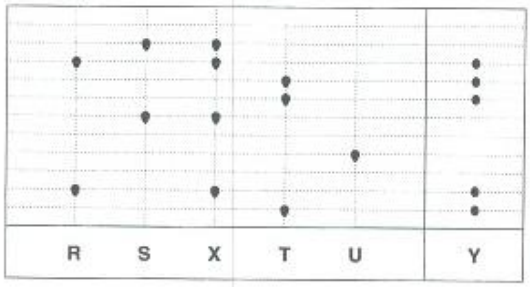
16. **A**
Add ethanol to dissolve the substance Q. Perform filtration to obtain Q (dissolved in ethanol) as the filtrate. Perform distillation to obtain Q as a distillate (the order in which Q appears as the distillate is dependent on its boiling point as compared to ethanol).

Must-Know Concept:
Separation techniques – solubility, separating solids from liquids and separating liquids from liquids

Paper 4

Section A

1. (a) **R** and **S**
(b) It is a pure substance.
(c)



2. Dry residue is obtained by crystallisation.

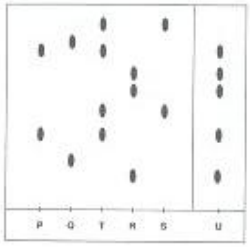
3. oxygen: The flame of the burning splint flares more brightly.
hydrogen: The flame is extinguished with a 'pop' sound.
carbon dioxide: The burning splint is extinguished.

4. (a)

titration number	1	2	3
final burette reading / cm³	25.10	28.60	**37.10**
initial burette reading / cm³	0.00	4.20	**12.50**
volume of liquid added / cm³	25.10	24.40	**24.60**

(b) Repeating a titration several times ensures that the readings obtained are consistent with one another. Hence, errors are minimised and the results are more accurate.

5. (a) (i) **P** and **S**
(ii)



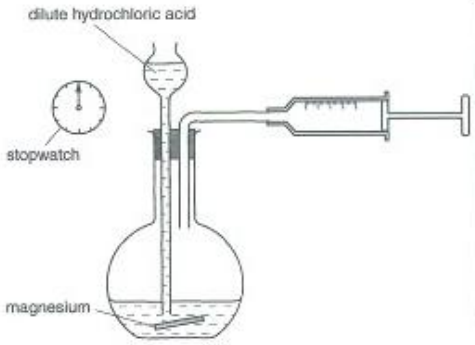
(b) (i) The inspector can gently heat a sample of drink **V** to evaporate off most of the water to prepare a concentrated solution of drink **V**.
(ii) Drink **V** contains tartrazine.
Drink **V** contains four different components.
Tartrazine consists of one component only.

Section B

1. (a) (i) 29 cm³
(ii) 7.6 minutes
(b) Heat the solution of magnesium chloride until it is saturated. Allow it to cool and crystallise to form magnesium chloride crystals. Filter the solution. Wash the crystals with distilled water and dry them.

2. (a) Hydrogen
(b) test: Test gas Z with a lighted splint.
observation: Gas Z extinguished the lighted splint with a 'pop' sound.

3.



4. (a) The hydrogen gas produced from the reaction escapes through the cotton wool.
   (b) Excess zinc ensures that all the sulfuric acid is used up in the reaction.
   (c) Filter the solution to remove the excess zinc pieces and collect the filtrate which is zinc sulfate solution. Heat the filtrate until it becomes saturated. Allow the saturated solution to cool so that the salt can crystallise. Filter the solution to collect the zinc sulfate crystals and wash the crystals with cold distilled water. Dry the crystals between a few sheets of filter paper.

5. (a) (i) process used in step 2 is filtration
   process used in step 3 is evaporation
   (ii) Step 3 is carried out to remove excess water gradually so that the magnesium chloride solution becomes saturated. Magnesium chloride may decompose under strong heating.
   (b) Filter the liquid to collect the magnesium chloride crystals and wash the crystals with cold distilled water to remove impurities. Dry the crystals between a few sheets of filter paper.
   (c) name of gas: Carbon dioxide
   positive test for gas: Bubble the gas through limewater (calcium hydroxide). A white precipitate which dissolves upon further bubbling will be formed in the presence of carbon dioxide.

6. (a) fractional distillation
   (b) alkane: heptane
   explanation: Heptane has a lower boiling point than octane, thus it will boil first and be collected in the beaker first.

TOPIC 2A Kinetic Particle Theory

Paper 3

1. **A**
Based on the kinetic particle theory, gas molecules are a greater distance away from one another than liquid molecules. Gas molecules are not necessarily smaller than liquid molecules. Gas molecules move freely and liquid molecules move less freely than gas molecules but they do not have fixed positions. Only solid molecules vibrate about their fixed positions.

Must-Know Concept:
Recall the distances between the particles in solids, liquids and gases.

2. **D**
A substance is a solid at a temperature which is lower than its melting point. Substances **A**, **B** and **C** are liquids at 20°C.

Must-Know Concept:
Define solids and their state of matter at a temperature below their melting point.

3. **C**
When the surrounding temperature decreases, molecules in a liquid lose energy (kinetic energy) as energy is given out by the molecules. The molecules will no longer have enough energy to move freely when temperature becomes low enough, and thus begin settling into fixed positions. The liquid then turns into a solid.

Must-Know Concept:
Heat energy is released as the particles of a liquid are attracted to one another to form a solid.

4. **B**
The movement of particles decreases during freezing (liquid to solid) and condensation (gas to liquid).

Must-Know Concept:
Kinetic particle theory

Paper 4

Section A

1. (a)

substance	melting point / °C	boiling point / °C	physical state at 20°C
R	–39	357	**liquid**
S	69	383	**solid**
T	–210	–196	**gas**
U	17	45	**liquid**

(b) During boiling, the liquid particles gain heat energy and start to move at a faster speed and become further apart. As the energy of the particles continues to increase, the particles break free of the forces of attraction between them and move freely at high speeds in random directions. At this point, all the liquid has become gas.

Section B

1. (a) **L** and **M**
   (b) condensation
   (c) The substance is undergoing the freezing process between time **K** and time **L**. The particles were closely packed and irregularly arranged initially but become very closely packed and regularly arranged. The particles were able to slide past each other initially but can now only vibrate about their fixed positions.

TOPIC 2B Atomic Structure

Paper 3

1. **C**
   Protons and neutrons are found in the nucleus while electrons are arranged in shells around the nucleus of the atom.

   Must-Know Concept:
   Properties of a nucleus

2. **B**
   A positive ion is formed by losing electron(s). As a result, the number of protons present is greater than the number of electrons, giving rise to an overall positive charge.

   Must-Know Concept:
   Formation of a cation

3. **A**
   Isotopes of the same element have the same number of protons (and electrons) but different number of neutrons.

   Must-Know Concept:
   Know the definition of isotope.

4. **D**
   An electron has a charge of –1. A neutron has no charge. A proton has a charge of +1.

   Must-Know Concept:
   Properties of the subatomic particles

5. **A**
   An electron is a negatively charged sub-atomic particle. It carries a –1 charge and has a negligible relative mass of $\frac{1}{1840}$. A neutron is an electrically neutral particle. It has 0 charge. A proton is a positively charged sub-atomic particle. It carries a +1 charge.

   Must-Know Concept:
   Properties of the subatomic particles

6. **D**
   Option (A), option (B) and option (C) are atoms as the number of protons is the same as the number of electrons. An ion is a charged particle, therefore the number of protons is not equal to the number of electrons.

   Must-Know Concept:
   Definition of ions

7. **A**
   In an atom, the number of protons is the same as the number of electrons. For an element represented in the form of ${}^{X}_{Z}A$, X is the mass number and Z is the proton number of the element. Since the charge of an atom is balanced, the number of electrons and protons is the same.

   Must-Know Concept:
   Relating number of electrons from atomic number

8. **B**
   The relative mass of an electron and a proton to a neutron is $\frac{1}{1840}$ and 1 respectively. Hence, the nucleus contains most of the mass of the atom. The nucleus and electrons do not repel each other as the nucleus contains protons which are positively charged.

   Must-Know Concept:
   Properties of the subatomic particles

9. **D**
An electron has a relative charge –1. Its relative mass is $\frac{1}{1836}$. A neutron has a relative charge 0 and relative mass 1 (Option A). A proton has a relative charge +1 and relative mass $\frac{1}{1836}$.

Must-Know Concept:
Properties of an electron

10. **C**
The nucleus of an atom contains protons and neutrons only. The electrons of the atom orbit around the nucleus of the atom.

Must-Know Concept:
Structure of an atom

11. **D**
Isotopes are atoms of the same element that have the same number of protons but different number of neutrons. $^{1}_{1}H$ has one proton and no neutrons. C and D have 1 proton and are hydrogen. C is not an atom, but an ion H^-.

Must-Know Concept:
Definition of isotopes

12. **C**
Isotopes are atoms of the same element with the same number of protons but a different number of neutrons.

Must-Know Concept:
Definition of isotopes

Paper 4
Section A

1. (a) Isotopes are atoms of the same element with the same number of protons and electrons, but different number of neutrons.
(b) number of electrons = 18
number of neutrons = 40 – 18
= 22

2. (a) 2, 4
(b) 2, 8, 8

3.

name of particle	number present in one atom of $^{13}_{6}C$
proton	6
neutron	7
electron	6

Section B

1. (a)

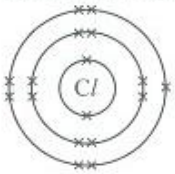
atom	symbol	number of protons	number of electrons	number of neutrons
chlorine-35	$^{35}_{17}Cl$	**17**	**17**	**18**
chlorine-37	$^{37}_{17}Cl$	**17**	**17**	**20**

(b) The two different isotopes of chlorine, ^{35}Cl and ^{37}Cl, occur naturally in the ratio 3:1, resulting in a relative atomic mass of 35.5 for *Cl*.

2. (a)

	sodium atom	chlorine atom
number of protons	11	**17**
number of electrons	11	17
arrangement of electrons	**2, 8, 1**	2, 8, 7

(b) Protons and neutrons
(c)



(d) A chlorine atom has 7 valence electrons. It gains one electron from another atom to become a chloride ion, Cl^-, with a –1 charge.

3. (a) $^{54}_{26}Fe$ contains 28 neutrons but $^{57}_{26}Fe$ contains 31 neutrons.
(b) 57
(c) 26

TOPIC 2C Structure and Properties of Materials, Ionic Bonding and Covalent Bonding

Paper 3

1. **C**
Option C shows a mixture of different atoms. Option B shows a compound in which its molecules are formed by two different types of atoms bonded together. Options A and D show atoms/molecules of elements.

Must-Know Concept:
Representation of a mixture

2. **B**
A covalent bond is a bond formed by the sharing of a pair of electrons. Hence, there are no free electrons for conduction of electricity.

Must-Know Concept:
Properties of covalent molecules

3. **C**
The carbon atom shares one of its 4 valence electrons with each hydrogen atom. 1 carbon atom is bonded to 4 hydrogen atoms.

Must-Know Concept:
Finding number of electrons used in bonding from structural formulae

4. **D**
One molecule of ethanol, C_2H_5OH, contains 2 carbon atoms, 6 hydrogen atoms and 1 oxygen atom. 2 + 6 + 1 = 9; There are 9 atoms in one molecule of ethanol.

Must-Know Concept:
Finding number of atoms from chemical formulae

5. **D**
An element is made up of only one type of atom. Option A shows only one diatomic element. Options B and C show a mixture of an element and a compound.

Must-Know Concept:
Representation of a mixture

6. **A**
The hydrogen atom is covalently bonded to the chlorine atom in a molecule of hydrogen chloride. Covalent bonds are characterised by the sharing of electrons. From the diagram, hydrogen shares its only electron with chlorine, enabling chlorine to achieve a stable electronic configuration. At the same time, chlorine shares one of its valence electrons with hydrogen, enabling hydrogen to achieve a stable electronic configuration as well. Protons are found within the nucleus of an atom and they do not take part in bonding.

Must-Know Concept:
Formation of covalent molecules

7. **A**
X is a compound as it is formed through a chemical reaction between zinc and oxygen. Zinc is an element as it is a pure substance that cannot be broken down into simpler substances. Air is a mixture as it is made up of nitrogen, oxygen and other gases.

Must-Know Concept:
Difference between element, compound and mixture

8. **C**
Ionic compounds have giant lattice structures. A lot of energy is required to break the strong electrostatic forces between the ions, so ionic compounds have high melting points. The ions in ionic compounds are held in fixed positions in the giant lattice structures, so they are hard and rigid in shapes. Ionic compounds cannot conduct electricity when they are in the solid state due to the lack of mobile ions and most ionic compounds dissolve readily in water.

Must-Know Concept:
Properties of ionic compounds

9. **D**
Ionic compounds contain ionic bonds which are strong electrostatic forces of attraction between positive and negative ions. They have giant lattice structures. To overcome the strong attractive forces (to melt the ionic compound), a large amount of heat energy is required, hence resulting in the ionic compounds having high melting points.

Must-Know Concept:
Properties of ionic compounds

10. **B**
All the positive charges must equal all the negative charges in an ionic compound. The anion present in the ionic compounds is Cl^-. A magnesium atom loses 2 electrons to form a magnesium ion, Mg^{2+}, to balance out the two negative charges in $MgCl_2$. A potassium atom loses 1 electron to form a potassium ion, K^+, to balance out the negative charge in KCl.

Must-Know Concept:
Formation of ions

11. **C**
R and S are elements as there is only one type of atom in the arrangement of particles. T is a compound as it shows the arrangement of particles of a solid ionic compound. U is a mixture as it shows the arrangement of particles of an alloy.

Must-Know Concept:
The differences between elements, compounds and mixtures

12. **D**
Aluminium, Al, belongs to Group III. Elements of Group III form ions with a charge of 3+ while sulfate ion has a charge of 2–.

Must-Know Concept:
How to balance a chemical formula and know the chemical formula of sulfate

13. **B**
Ionic compounds have giant lattice structures. A large amount of energy is required to overcome the strong electrostatic forces of attraction between the oppositely-charged ions, so ionic compounds have high melting points. Most ionic compounds dissolve readily in water but are insoluble in organic solvents. Ionic compounds cannot conduct electricity when they are in solid state due to the lack of mobile ions that carry electric charges. In liquid state, ionic compounds consist of free-moving ions that carry electric charges.

Must-Know Concept:
Properties of ionic compounds such as sodium chloride

14. **B**
B is made up of two elements and a compound (different elements chemically combined together).

Must-Know Concept:
Definitions of compound and mixture

15. **C**
Sodium loses one electron to form Na^+ while chlorine gains one electron to form Cl^- to fulfil the octet structure (eight valence electrons).

Must-Know Concept:
Metals generally lose electron(s) to form cations and non-metals generally gain electron(s) to form anions.

Paper 4
Section A

1. (a) Ionic bonding
   (b) **Q**

2. (a)

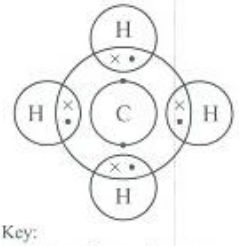
substance	description
carbon dioxide	**B**
water	**B**
crude oil	**D**
brass	**C**

   (b) (i) CaO
   (ii) H_2SO_4
   (iii) $Al_2(SO_4)_3$

3. (a) An oxygen atom gains two electrons to become an oxide ion, O^{2-}.
   (b) Al_2O_3

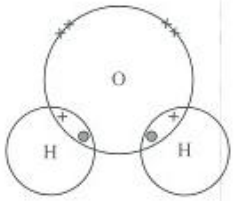
4. (a) Carbon dioxide

   Explanation:
   Look at the number of protons to identify the elements as each element has a unique proton number. A carbon atom has 6 protons and an oxygen atom has 8 protons.
   (b) Covalent bonding
   (c)



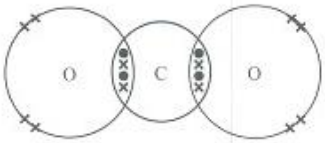
Key:
• electron from carbon atom
× electron from hydrogen atom

5.



Key:
● electron of hydrogen
× electron of oxygen

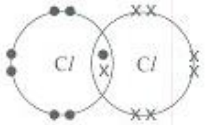
6.



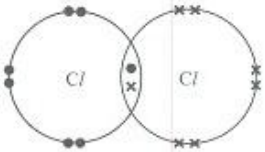
● electron of C
× electron of O

Section B

1. (a) N = Nitrogen
   P = Phosphorous
   K = Potassium
   (b) It is highly soluble.

2. 

3. (a) Sodium chloride has a high melting point because a large amount of energy is needed to overcome the strong ionic bonds formed between sodium and chloride ions.
   (b) In the solid state, sodium and chloride ions are held in an ionic lattice structure so there are no free mobile ions. When sodium chloride is dissolved in water or melted, the sodium and chloride ions become mobile and are free to carry electrical charges.

4. 

5. Each aluminium atom loses three electrons to form an Al^{3+} ion. Each chlorine atom gains one electron to form a Cl^- ion.

TOPIC 3 Formulae and the Mole Concept

Paper 3

1. **C**
Molecular formula of a molecule denotes the number of different atoms that make up a single molecule of a compound. In one molecule of the compound shown, there are four atoms of X and six atoms of Y. Hence, the molecular formula of the compound is X_4Y_6. The simplest ratio of atoms in a compound is represented by its empirical formula.

Must-Know Concept:
Writing formula of a compound

2. **D**
The relative molecular mass of a flourine molecule, F_2, is $(2 \times 19 =) 38$.

Must-Know Concept:
Calculating relative molecular mass

3. **B**
Haematite, or iron(III) oxide, is written as Fe_2O_3.

Must-Know Concept:
Writing formula of a compound

4. **D**
The balanced chemical equation is as follows:
$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$.
Hence, x is 3, y is 2 and z is 3.

Must-Know Concept:
Balancing of equation

5. **A**
The relative atomic mass of an atom is defined as the average mass of one atom of that element compared to $\frac{1}{12}$ of the mass of one carbon-12 atom.

Must-Know Concept:
Definition of relative atomic mass

6. **B**
From the graph, the sharpest rise in the pH of vinegar occurs when 3 portions of lime are used. Hence, 3 portions of lime are required to neutralise 20 cm^3 of vinegar. 40 cm^3 of vinegar is twice the volume of 20 cm^3. Therefore, the number of portions of lime needed would be $(2 \times 3 =) 6$.

Must-Know Concept:
pH of a neutralised substance is 7

7. **C**
$2SO_2 + O_2 \rightarrow 2SO_3$
2 moles of sulfur dioxide react with 1 mole of oxygen to form 2 moles of sulfur trioxide.

Must-Know Concept:
Balancing of equation

8. **C**
Two hydrogen atoms bond with one nitrogen atom to form NH_2. One carbon atom bonds with one oxygen atom to form CO. Two NH_2 molecules bond to a CO molecule to form $(NH_2)_2CO$.

Must-Know Concept:
Writing formula of a compound

9. **C**
Solid copper carbonate reacts with aqueous hydrochloric acid to form aqueous copper chloride, water and carbon dioxide gas.

Must-Know Concept:
How to read the state symbols in the chemical equation

10. **B**
Relative molecular mass of $X_2O = 44$
$2(X) + 16 = 44$
$2X = 44 - 16$
$X = 28 \div 2$
$= 14$
Relative atomic mass of X = 14

Must-Know Concept:
Calculating relative molecular mass

11. **C**
Add the number of atoms of each element (denoted by the subscript) together. C has a total of 15 atoms.

Must-Know Concept:
The subscript in a chemical formula shows the number of atoms for that element.

12. **A**
Apply the crisscross method in the reverse direction. The charges on O and *Cl* are 2– and 1– respectively. Hence, both Cr have a charge of 3+.

Must-Know Concept:
The crisscross method to work out a chemical formula

Paper 4
Section A

1.

name of substance	formula of substance	number of atoms of each element
methane	CH_4	1 carbon 4 hydrogen
iron(III) oxide	Fe_2O_3	**2 iron** **3 oxygen**
sulfuric acid	H_2SO_4	2 hydrogen 1 sulfur 4 oxygen
sulfur dioxide	SO_2	**1 sulfur** **2 oxygen**

2. (a) (s) stands for solid and (g) stands for gas.
(b) $2Mg + O_2 \rightarrow 2MgO$
A_r of Mg = 24
Number of moles in 12 g Mg = $\frac{12}{24}$
= 0.5 mol
Mass of MgO produced = 0.5 × (24 + 16)
= 20 g

3. (a) Potassium (K^+)
(b) 4
(c) $MgCl_2$

4. (a) M_r of $MgSO_4 = 24 + 32 + 4(16) = 120$
(b) (i) Magnesium sulfate is soluble in water.
(ii) Number of moles of Mg = $\frac{\text{mass}}{M_r}$
= $\frac{6}{24}$
= 0.25 mol
1 mol of Mg : 1 mol of $MgSO_4$
Maximum mass of $MgSO_4$
= no. of mol × M_r of $MgSO_4$
= 0.25 × 120
= 30 g

5. (a)

gas	formula	relative molecular mass M_r	pH of aqueous solution after gas has been bubbled through water
ammonia	NH_3	**17**	10
carbon dioxide	CO_2	44	6
hydrogen	H_2	2	7
oxygen	O_2	32	7

(b) Number of moles of O_2 in 96 g of oxygen
= $\frac{96}{32}$
= 3 mol

6. M_r of $C_3H_6 = 3 \times 12 + 6$
= 42
Number of moles of C_3H_6 = $\frac{21}{42}$
= 0.5 mol

7. (a)

formula	relative formula mass, M_r
$Zn(NO_3)_2$	$65 + 2[14 + 3(16)] =$ **189**
$NaCl$	23 + 35.5 = **58.5**

(b) Mass = moles × M_r
= 0.2 × 189
= 37.8 g

8. Mass = no. of moles × M_r
= 2 × (12 + 2 × 16)
= 88 g

Section B

1. (a) M_r of NH_4NO_3
= 14 + 4 × 1 + 14 + 3 × 16
= 80
(b) M_r of NH_4
= 14 + 3 × 1
= 17
$\frac{240}{80} \times 17 = 51$ tonnes
Mass of ammonia = 51 tonnes

2. (a) $^{6}_{3}Li$
(b) Li^{+}
(c) Isotopes

3. $2Na\,(s) + Cl_2\,(g) \rightarrow 2NaCl\,(s)$

4. (a) $2HCl\,(aq) + MgCO_3\,(s) \longrightarrow MgCl_2\,(aq) + CO_2\,(g) + H_2O\,(l)$
(b) M_r of $MgCO_3$ = 24 + 12 + 3(16)
= 84
Number of moles of $MgCO_3$ = 16.8 ÷ 84
= 0.2 mol

5. Amount of $Ca(OH)_2 = \frac{\text{mass}}{M_r}$
$= \frac{14.8}{40 + 2(16) + 2(1)}$
= 0.2 mol

6. (a) $3Na_2CO_3(aq) + 2AlCl_3(aq) + 3H_2O(l) \rightarrow 2Al(OH)_3(s) + 6NaCl(aq) + 3CO_2(g)$
(b) (s) = solid (aq) = aqueous
(*l*) = liquid (g) = gaseous

TOPIC 4 Acids, Bases and Salts

Paper 3

1. **D**
Carbon and sulfur form acidic oxides.
Magnesium forms a basic oxide.
Nitrogen forms a neutral/acidic oxide.

Must-Know Concept:
Classification of oxides

2. **B**
Acidic soil can be limed by adding calcium hydroxide, a base, to reduce the acidity of the soil.

Must-Know Concept:
Substance used to control pH in soils

3. **C**
Hydrochloric acid will react with copper(II) oxide or copper(II) carbonate to produce copper(II) chloride. Copper is unreactive, hence it will not react with dilute hydrochloric acid.

Must-Know Concept:
Characteristic chemical properties of acids, reactivity of metals

4. **A**
Acid will react with carbonates to produce carbon dioxide.

Must-Know Concept:
Characteristic chemical properties of acids

5. **D**
The reaction between acid and alkali is called neutralisation. The products of any neutralisation reaction are salt and water.

Must-Know Concept:
Characteristic chemical properties of acids

6. **B**
Oxides of metals are basic while oxides of non-metals are acidic. Metal oxides have basic properties such as being able to react with acids to form salt and water.

Must-Know Concept:
Classification of oxides

7. **B**
In general, metals form basic oxides and non-metals form acidic oxides. Amphoteric oxides are a special group of oxides that exhibit both acidic and basic properties. Common amphoteric oxides include aluminium oxide, zinc oxide, lead(II) oxide and many transition metal oxides. Carbon is a non-metal so carbon dioxide is an acidic oxide. Magnesium is a metal so magnesium oxide is a basic oxide.

Must-Know Concept:
Classification of oxides

8. **C**
A solution of pH 5 is acidic. The oxide of a non-metallic element is an acidic oxide. An acidic oxide dissolves in water to form an acidic solution.

Must-Know Concept:
Classification of oxides

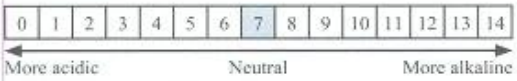
9. **B**
Calcium hydroxide is a base. Adding calcium hydroxide to the soil increases the pH of the soil. Only the blackcurrant plant grows best at a pH higher than 6.5.

Must-Know Concept:
Importance of controlling pH in soils

10. **A**
metal + acid ⟶ salt + hydrogen

Must-Know Concept:
Characteristic chemical properties of acids

11. **B**
The pH scale of 0 to 14 is used to indicate whether a substance is acidic, neutral or alkaline. Any pH value closer to pH 7 denotes a weaker acid or alkali.



Calcium hydroxide increases the pH of the soil, so it is alkaline.

Must-Know Concept:
Importance of controlling pH in soils

12. **D**
The pH ranges from 0 to 14, with 7 being neutral, values below 7 being acidic and values above 7 being alkaline. Sodium bicarbonate has a pH of 9 which is closer to the pH of neutral than to the pH of a strong alkali.

Must-Know Concept:
How to read the colours of Universal Indicator

13. **D**
Alkali reacts with ammonium salts to produce salt, ammonia gas and water when heated gently.

Must-Know Concept:
The chemical reaction of alkali and ammonium salts

14. **B**
In general, metals form basic oxides and non-metals form acidic oxides. Amphoteric oxides are a special group of oxides that exhibit both acidic and basic properties. Common amphoteric oxides include aluminium oxide, zinc oxide and lead(II) oxide. Sodium is a metal, hence, sodium oxide is a basic oxide. Sulfur is a non-metal, hence, sulfur dioxide is an acidic oxide.

Must-Know Concept:
Classification of oxides

15. **C**
The heating of sodium hydroxide and ammonium nitrate produces sodium nitrate, water and ammonia gas. Ammonia gas is alkaline, hence the damp Universal Indicator paper turns blue.

Must-Know Concept:
Colour changes in common acid-base indicators such as the Universal Indicator; reactions between alkalis and ammonium compounds

16. **B**
W is amphoteric as it reacts with both HC*l* and NaOH to produce salts. X is basic as it only reacts with HC*l* to produce a salt. Y is acidic as it only reacts with NaOH to produce a salt.

Must-Know Concept:
Reactions of acids and bases

17. **D**
PbI_2 is formed in a precipitation reaction between the two reactants. Since it is an insoluble salt, it is separated from the two reactants by filtration. Pure PbI_2 is obtained by washing and drying the salt.

Must-Know Concept:
The preparation of an insoluble salt and how the salt prepared can be separated from a solution

Paper 4
Section A

1. (a) Green/Dark green/Blue-green *(Any one)*
   (b) Mineral water is slightly alkaline.

2. Carbon dioxide

3. (a) $2HCl\,(aq) + Mg(OH)_2\,(aq) \rightarrow MgCl_2\,(aq) + 2H_2O\,(l)$
   (b) Neutralisation

4. (a) acid: Hydrochloric acid
base: Sodium hydroxide
(b) 7

5. (a) **J**
(b) **M**
(c) **L**

6. (a) H^-
(b) OH^-
(c) (i) Neutralisation
(ii) Sodium chloride
(iii) $HCl + NaOH \rightarrow NaCl + H_2O$

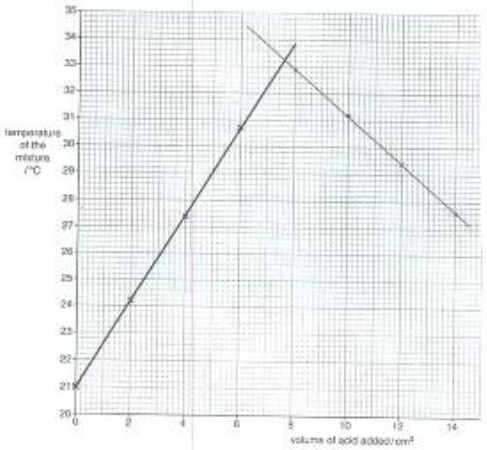
Section B

1. (a) $Mg + 2HCl \longrightarrow MgCl_2 + H_2$
(b) test: Use a lighted splint
observation: The lighted splint will extinguish with a 'pop' sound.

2. (a) The soil is acidic and not suitable for growing peas.
(b) Calcium hydroxide
(c) Calcium hydroxide will neutralise the acidity of the soil and increase its pH to become alkaline.
(d) Blue

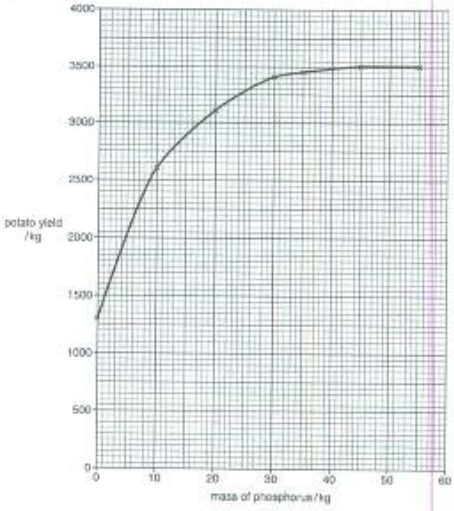
3. (a) 48 cm^3
(b) All of the magnesium metal had reacted with hydrochloric acid.
(c) $Mg\,(s) + 2HCl\,(aq) \rightarrow MgCl_2\,(aq) + H_2\,(g)$

4. (a) Burette
(b) (i) and (ii)



(c) (i) 7.6 cm^3 *(Accept answers that are ± 0.1 cm^3)*
(ii) 12.3°C *(Accept answers that are ± 0.1°C)*
(iii) $H^+ + OH^- \rightarrow H_2O$
(d) test: Add a drop of Universal Indicator into each solution.
observation before: The solution turned blue when the Universal Indicator was added.
observation after: The solution turned red when the Universal Indicator was added.

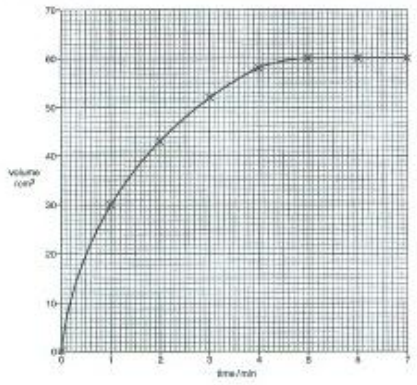
5. (a) Nitrogen and potassium
(b) (i)



(ii) Adding 30 kg of phosphorus to each plot is the lowest mass of phosphorus needed to obtain a good potato yield (3400 kg) near the maximum yield (3500 kg).
(c) Mass of phosphorus in each bag
= 50 kg × 4%
= 2 kg
Total number of bags needed
= 30 kg ÷ 2 kg
= 15
(d) (i) Calcium hydroxide
(ii) Calcium hydroxide is an alkali with hydroxide ions which will reduce the concentration of hydrogen ions in the soil, increasing the pH value.

6. (a) name of gas **X**: hydrogen
positive test for this gas: Place a lighted splint at the mouth of a test tube containing gas **X**. If gas **X** is hydrogen, it will extinguish the lighted splint with a 'pop' sound.

(b) (i) and (ii)



(iii) 5
Explanation:
– The gradient of the graph decreases to 0 when the reaction is completed.

(iv) All the calcium has reacted with the water so no more hydrogen gas is produced.

7. (a) (i) 29

(ii) When the temperature is increased, the percentage of ammonia decreases.

(b) (i) It means that the substance, ammonium sulfate in this case, is dissolved in water.

(ii) M_r of $(NH_4)_2SO_4$:
$2(14 + 4) + 32 + 4 \times 16 = 132$

(iii) Y

(iv) The acidity of the soil

(v) If they were allowed to mix, the ammonium sulfate (ammonium salt) would react with calcium hydroxide (base) to form a salt, ammonia gas and water which would result in a loss of the nitrogenous fertiliser.
$(NH_4)_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2NH_3 + 2H_2O$

TOPIC 5 The Periodic Table: Periodic Trends and Group Properties

Paper 3

1. **C**
The halogens become darker and have a higher melting point and boiling point down the group. Therefore, astatine would be expected to be a black solid.

Must-Know Concept:
Trend in colour and physical state of elements down Group VII

2. **D**
In the Periodic Table, elements are arranged in order of proton number (or atomic number).

Must-Know Concept:
Relationship between proton number and position of element in the Periodic Table

3. **D**
The elements in the Periodic Table are arranged according to their proton numbers.

Must-Know Concept:
Relationship between proton number and position of an element in the Periodic Table

4. **D**
Group VII elements are non-metals and exist as small molecules, each of which contains two atoms. Hence, X is in Group VII of the Periodic Table. Group I and II elements are metals, which cannot form diatomic molecules. Group 0 elements are called the noble gases, which consist of single atoms and are monoatomic.

Must-Know Concept:
Properties of Group VII elements

5. **D**
Elements of the same group in the Periodic Table will have the same number of valence electrons as its group number. Down the group, proton number increases as the atomic size of the elements increases.

Must-Know Concept:
Relationship between group number and number of valence electrons, trend in proton number down a group

6. **B**
Down Group I, the melting point of the metals decreases due to less energy needed to break the weaker attractive forces. However, reactivity increases down the group due to valence electrons being lost more easily.

Must-Know Concept:
Trends in melting points and reactivity with water down Group I

7. **A**
For option B, lithium (Li) is a metallic element. For options C and D, there are only two different elements in each compound.

Must-Know Concept:
Identification of non-metals from their positions in the Periodic Table

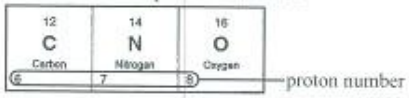
8. **C**
Elements in the Periodic Table are arranged in increasing proton numbers from the left to the right. Each position to the right is an increase of 1 in proton number. Since, Z is three positions to the right of X, the proton number of Z is three more than X (i.e. the proton number of X is three less than Z).

Must-Know Concept:
Relationship between proton number and the relative positions of elements in the Periodic Table

9. **C**
Down Group I, reactivity increases as valence electrons are lost more easily. This is due to the electrons being less strongly attracted to the nucleus of each atom as the atom increases in size. Down Group VII, reactivity decreases. This is due to electrons being less easily taken in by a Group VII element to form a stable electronic configuration.

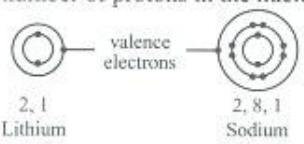
Must-Know Concept:
Trends in reactivity down Group I and Group VII

10. **C**
The elements in a Periodic Table are arranged in order of the proton number.



Must-Know Concept:
Relationship between proton number and position of an element in the Periodic Table

11. **C**
The elements in a group, such as lithium and sodium, have the same number of valence electrons, which are the electrons in the shell furthest from the nucleus. The elements in a period have the same number of electron shells. All elements except hydrogen have the same number of electrons in the shell closest to the nucleus. Different elements have different number of protons in the nucleus.



Must-Know Concept:
Relationship between the group number of an element and its number of valence electrons

12. **B**
The reactivity of halogens decreases, while the melting points and proton numbers of halogens increase down Group VII.
X is fluorine or chlorine, a highly reactive gas. Z is bromine, a reddish-brown liquid. Y, which is less reactive than Z (bromine), may be iodine or astatine. Since the proton number increases down the group, X comes first followed by Z and Y.

Must-Know Concept:
Trends in physical states, reactivity and colour down Group VII

13. **D**
An electronic structure of 2, 8, 6 shows that element R is placed in Group VI in the Periodic Table as the number of valence electrons is the same as the group number of the element. Elements in the same group have similar properties and the same number of valence electrons, hence element D will have properties most similar to R.

Must-Know Concept:
Determination of position of an element based on its given electronic configuration, relationship between group number of an element and its properties

14. **B**
A reactive metal reacts with water to form a metal hydroxide and hydrogen gas. Universal Indicator paper turns blue when tested with metal hydroxides and lighted splint gives off a 'pop' sound in the presence of hydrogen gas.

Must-Know Concept:
The reaction of reactive metals with water, gas tests and the pH level of metal hydroxides

15. **A**
Elements in the same group have the same number of electrons in the outermost valence shell. Elements in Group II are metals with two valence electrons.

Must-Know Concept:
How elements are sorted in groups and their similarities

16. **A**
Fluorine is placed above chlorine in Group VII. Hence, it is a gas at room temperature and has relatively lower density and melting point than those of chlorine.

Must-Know Concept:
Trend in physical state and colour of elements down Group VII

17. **B**
All elements in the same group have the same number of valence electrons (electrons in the outermost shell). Group II elements have two valence electrons.

Must-Know Concept:
Similarity/similarities among elements in the same group

18. **C**
Group VII trends:
- intensity of colour of elements increases down the group
- melting point of elements increases down the group

Must-Know Concept:
Group trends of Group VII elements

19. **C**
The element with A_r 16 has 8 protons in its nucleus. It is a non-metal that has 6 valence electrons and forms an anion with a charge of 2–.

Must-Know Concept:
Identification of an element using its A_r and the Periodic Table

Paper 4
Section A

1. (a) A and G
   (b) F

2. (a) **Q**
   (b) **S**
   (c) **Q** and **T**
   Explanation:
   Metals form basic oxides.
   Elements in the same group have the same number of valence electrons.

Section B

1. (a)

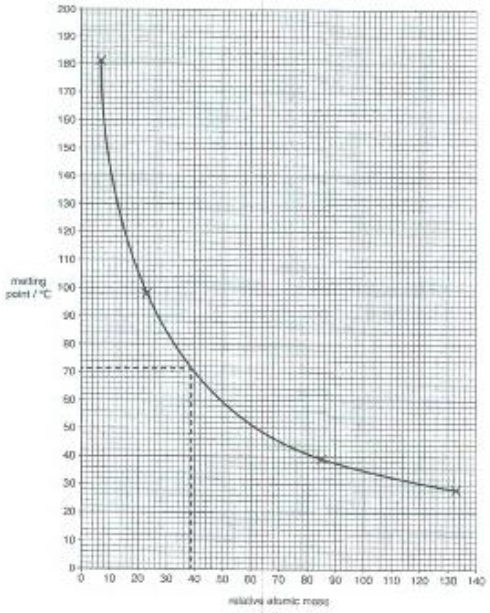
element	proton number	arrangement of electrons
lithium	3	**2, 1**
sodium	**11**	2, 8, 1
potassium	**19**	**2, 8, 8, 1**

   (b) The three elements have similar electronic structures with the same number of outermost electrons (i.e. one).
   (c) The melting point decreases from lithium to potassium.

2. (a) Fluorine/Bromine/Iodine
   (Any two)
   (b) (If student chooses *fluorine* and *bromine*):
   bromine, chlorine, fluorine
   (If student chooses *fluorine* and *iodine*):
   iodine, chlorine, fluorine
   (If student chooses *bromine* and *iodine*):
   iodine, bromine, chlorine

3. Period 4

4. (a) and (b)



(c) 71°C
(d) The elements have one valence electron.

5. (a) $Cl_2 + 2KI \rightarrow 2KCl + I_2$
(b) The colourless solution turns brown.
Explanation:
Chlorine is more reactive than iodine, so it will displace iodine from potassium iodide.

6. (a) The group in which an element is found is the same as the last digit/number in the electronic structure.
(b) The period in which an element is found is the same as the number of digits found in the electronic structure.
(c) Moving from left to right of the Periodic Table, the elements change from metallic to non-metallic in character.

TOPIC 6 Properties of Metals, Reactivity Series, Extraction of Metals, Recycling of Metals and Iron

Paper 3

1. **A**
Sodium is a Group I element (alkali metal) and is, like most metals, a good conductor of electricity. However, unlike most metals, it is soft, has low density and a low melting point.

Must-Know Concept:
Properties of a Group I metal

2. **C**
An alloy is a mixture of elements whereby metallic elements are present in large proportions. An alloy is made up of atoms of different sizes that disrupt the orderly arrangement of the atoms and prevent sliding of the layers of atoms.

Must-Know Concept:
Arrangement of atoms in an alloy

3. **A**
Metals lower down in the reactivity series are easier to extract from their ores. Hence, copper and lead can be reduced by heating their oxides with carbon. Magnesium is higher up in the reactivity series and is more difficult to extract. It is usually extracted by electrolysis of its molten ore.

Must-Know Concept:
Extraction of metals through heating with carbon

4. **B**
Haematite is made of iron oxide. When pure iron is extracted from haematite, the oxygen atoms will combine with carbon monoxide to form carbon dioxide.

Must-Know Concept:
Reaction taking place in the blast furnace

5. **B**
All metals conduct electricity due to the presence of a sea of delocalised electrons. Metals are not soluble in water. Some metals, such as rubidium and caesium, have low melting points. Unreactive metals, such as copper and gold, do not react with dilute sulfuric acid.

Must-Know Concept:
Properties of metals

6. **A**
An alloy is a mixture of elements whereby metallic elements are present in large proportions. An alloy is made up of atoms of different sizes that disrupt the orderly arrangement of the atoms and prevent sliding of the layers of atoms.
Any solid is made up of atoms that are tightly packed together.

Must-Know Concept:
Arrangement of atoms in an alloy

7. **B**
Copper has no reaction with water or steam. Hot magnesium and hot zinc react with steam to form hydrogen gas.

Must-Know Concept:
Reactivity of metals with steam

8. **C**
Limestone is used in the extraction of iron to convert impurities such as sand (silicon dioxide) into slag (calcium silicate).

Must-Know Concept:
Role of limestone in a blast furnace

9. **C**
Coating with zinc (galvanising) and painting the surface of iron with a layer of substance will prevent it from rusting. Dissolved oxygen in salt water will speed up rusting.

Must-Know Concept:
Methods to prevent rust formation

10. **A**
All metals can conduct electricity due to the presence of free, mobile electrons in their structures. Not all metals are hard because Group I metals (alkali metals) are soft metals. Group I and II metals have low melting points but transition metals generally have high melting points and exist as solids at room temperature, except mercury. Not all metals react with water. Unreactive metals such as gold, silver and platinum do not react with water.

Must-Know Concept:
Properties of metals

11. **B**
Y is the most reactive metal out of the three metals because it is the only metal that reacts with water. X is the least reactive because it does not react with either water or steam.

Must-Know Concept:
Determination of reactivity of metals based on their reactivity with water and steam

12. **C**
The advantages of recycling metals are that it saves the cost of extracting metals from their ores, and it helps to meet the increasing demand for metals without using up the limited supply of natural metal ores too quickly.

Must-Know Concept:
Reasons for recycling metals

13. **D**
Iron(III) oxide is the main substance found in haematite. Copper and aluminium are not found in haematite.

Must-Know Concept:
Composition of haematite

14. **D**
Recycling helps us to conserve limited natural resources and reduce the amount of waste produced. Metal ores are non-renewable resources. Therefore, it is important to cut down on extraction of metal ores from the Earth. Excessive landfill rubbish sites result in land pollution where toxic substances from the rubbish seep into oceans and seas, polluting the waters and endangering marine life.

Must-Know Concept:
Reasons for recycling metals

15. **D**
Aircraft bodies need to be light so that they are easily lifted into the air. Therefore, the density must be low. Aircraft bodies also need to be malleable to be easily bent and made into the shape of an aircraft. A brittle element may cause the aircraft body to break under high pressures when the aircraft is in the air.

Must-Know Concept:
Properties of metals that make them suitable for a given industrial application

16. **C**
When iron is exposed to moisture and air (oxygen), it reacts with the oxygen in the air to become iron oxide. This process is known as rusting. The water in the test tube rises as some oxygen has been used up and water enters the test tube to take the space previously occupied by oxygen.

Must-Know Concept:
Formation of rust

17. **C**
In general, metals are good conductors of heat and electricity. Metals also have high melting and boiling points.

Must-Know Concept:
Properties of metals

18. **B**
Carbon dioxide and sulfur dioxide are waste gases and are released from the top part of the furnace. Slag is less dense than molten iron. Hence, the iron leaves the furnace at X.

Must-Know Concept:
Process of metal extraction in a blast furnace

19. **A**
Most metals are good conductors of electricity and heat. Metals form basic oxides. Metals usually have high melting points as a lot of energy is required to overcome the strong forces of attraction between the positive metal ions and the 'sea of mobile electrons'.

Must-Know Concept:
Properties of metals

20. **C**
An alloy is a mixture of a metal with one or a few other elements. The different sizes of atoms in an alloy disrupt the regular arrangement of atoms in a pure metal. An alloy is thus stronger than a pure metal because the atoms of different sizes cannot slide past each other easily when a force is applied.

Must-Know Concept:
Arrangement of atoms in an alloy

21. **A**
Metals are recycled due to their limited supply in Earth and the increasing demand for them in industries.

Must-Know Concept:
Reasons for recycling metals

22. **D**
Rusting of metal occurs in the presence of water and oxygen. Zinc is more reactive than iron.

Must-Know Concept:
The order of metals in the reactivity series and the conditions for rusting

23. **D**
Metals of the same type are crushed together to obtain a pure metal. Metals are crushed for effective heating.

Must-Know Concept:
The concept behind the process of recycling of metals

24. **A**
An alloy is a mixture of metals. Aluminium and copper are metals. Statement 2 explains how alloys are made.

Must-Know Concept:
Definition of an alloy

25. **C**
There is no reaction between copper and steam as copper is unreactive. Metals such as magnesium and zinc react with steam to produce metal oxide and hydrogen gas.

Must-Know Concept:
The reactivity series of metals and their reaction with steam

26. **A**
The reactivity of elements in Group I and Group II increases down the groups due to the valence electrons being lost from the outermost shell more easily. Since potassium is placed below sodium in Group I, it is more reactive than sodium. Likewise, since calcium is placed below magnesium in Group II, it is more reactive than magnesium.

Must-Know Concept:
Trends in reactivity of elements down the Group and down the reactivity series

27. **B**
Metals are categorised as finite resources due to the limited amounts of ores in the Earth. Since the extraction of metals from their ores requires a continuous supply of energy that is generated from fossil fuels and the process is usually costly, recycling metals help to conserve the limited fossil fuel reserves in the Earth and the excessive costs incurred.

Must-Know Concept:
Recycling metals; reasons and advantages

28. **A**
As more carbon dioxide rises up the blast furnace during the series of chemical reactions occurring during iron extraction, the carbon dioxide reacts with more coke to form carbon monoxide. The carbon monoxide reduces the iron(III) oxide in haematite to iron.

Must-Know Concept:
Essential reactions in the extraction of iron using haematite, limestone and coke in the blast furnace

29. **B**

Both air (oxygen) and water should be present for rusting to take place. Hence, to prevent the iron bar from rusting, it has to be kept away from both oxygen and water. Coating with paint, covering with grease and electroplating are some of the methods used to prevent rusting.

Must-Know Concept:
Conditions necessary for rusting to occur and the methods to prevent it

30. **C**

An alloy is a mixture of metal and one or more elements. The presence of this/these other element(s) that has/have atoms of different size(s) upsets the orderly arrangement of the pure metal.

Must-Know Concept:
Definition of an alloy

31. **A**

The more reactive the metal, the more vigorous the reaction.

Must-Know Concept:
Position of metals in the reactivity series

32. **D**

Hydrogen and nitrogen do not react with iron and do not cause the water level to rise. Air only contains 21% of oxygen which reacts with iron.

Must-Know Concept:
Reactions that a metal undergoes

33. **B**

CO is the reducing agent which will reduce Fe_2O_3 in haematite to produce iron.
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Must-Know Concept:
The role of CO in the blast furnace

Paper 4

Section A

1. (a)

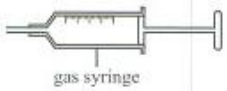
metal	letter V, W, X, Y or Z
calcium	W
copper	X
magnesium	Z
potassium	Y
sodium	V

(b) (i) Hydrogen

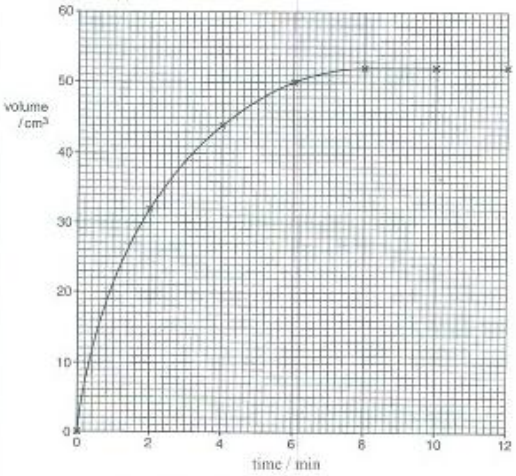
(ii) test: A lighted splint is brought near the gas.
observation: The gas extinguishes the lighted splint with a 'pop' sound.

Section B

1. (a)



(b) (i)



(ii) 48 cm^3

(iii) Either the calcium carbonate in the marble chips or the dilute hydrochloric acid has been used up in the reaction. Hence, no more gas is produced and the total volume of gas recorded remains constant.

(c) $CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

2. (a) (i) Zn (s) + H_2O (g) → ZnO (s) + H_2 (g)

(ii) calcium copper lead iron silver sodium

(b) (i) 81 cm^3

(ii) All the zinc had reacted with excess sulfuric acid.

(c) The diagram represents an alloy.

3. (a) From the list, the metals that were discovered much earlier are the less reactive metals such as copper, lead, iron and zinc. Since these metals are less reactive, they did not react as easily with surrounding elements, such as oxygen, as compared to the other more reactive metals. Hence, the less reactive metals remained in their original states and were more easily discovered and extracted.

(b) (i) **U**
(ii) **R**

4. (a) The layer of tin acts as a protective layer to protect the mild steel from rusting.

(b) 1. Recycling helps to conserve aluminium ore which is a natural resource.
2. Recycling reduces environmental problems related to extracting aluminium from its ores.

(c) Aluminium metal is soft/malleable.

5. (a) most reactive magnesium
zinc
iron
least reactive copper

(b) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

6. (a) (i) haematite; coke; limestone
(ii) Carbon monoxide/Carbon dioxide/ Nitrogen *(Any two)*

(b) element: Oxygen
compound: Water

(c) (i)

most reactive ⟶ least reactive

calcium	magnesium	iron	copper

(ii) cold water: no observed change
steam: reacts readily to form zinc oxide which is yellow when hot and white when cold

7. (a) The sodium darts around the water surface producing a hissing sound. Flames may be produced.
Explanation:
Sodium is less dense than water, so it floats on water. Sodium reacts with metal to produce hydrogen gas which pushes the sodium and produces the hissing sound.

(b) The colour of the Universal Indicator turns blue.
Explanation:
Sodium hydroxide which is an alkali is produced.

(c) $2Na\ (s) + 2H_2O\ (l) \longrightarrow 2NaOH\ (aq) + H_2\ (g)$

8. (a) Liquid **Q** is water.

(b) name of gas **R**: Hydrogen
positive test for gas **R**: Hydrogen extinguishes a lighted splint with a 'pop' sound.

(c) $Mg\ (s) + H_2O\ (g) \rightarrow MgO\ (s) + H_2\ (g)$

TOPIC 7 Air

Paper 3

1. **A**
CO is produced as a result of incomplete combustion of fossil fuels that contain carbon.
NO_2 is produced as a result of the internal combustion of the engine in vehicles.
SO_2 is produced as a result of combustion of fossil fuels.

Must-Know Concept:
Products formed by combustion of fossil fuel

2. **D**
The composition of air is 78% nitrogen, 21% oxygen and 1% carbon dioxide and other gases.
Therefore in 200 cm^3 of air, volume of nitrogen
$= \frac{78}{100} \times 200\ cm^3$
$= 156\ cm^3$ (approximately 160 cm^3)

Must-Know Concept:
Percentage composition of atmospheric air

3. **C**
The air contains 78% nitrogen, 21% oxygen and 1% of other gases such as carbon dioxide and noble gases.

Must-Know Concept:
Composition of atmospheric air

4. **D**
Burning of coal produces sulfur dioxide gas. The limestone (calcium carbonate) walls are gradually worn away as sulfur dioxide reacts with calcium carbonate to form carbon dioxide and calcium sulfite.

Must-Know Concept:
Effects of pollutants on the environment

5. **C**
The combustion of fossil fuels produces harmful gases such as carbon monoxide, methane and sulfur dioxide. Nitrogen dioxide is produced from lightning and internal combustion engines of vehicles.

Must-Know Concept:
Products formed by combustion of fossil fuel

6. **D**
Iron rusts the most in the presence of water and oxygen. The water in the tube will rise to take the space previously occupied by oxygen. Air only contains approximately 21% of oxygen, so the water in the tube containing air will rise less than the water in the tube containing oxygen only.

Must-Know Concept:
Reaction of iron with oxygen in the presence of moisture

7. **B**
The composition of air is 78% nitrogen, 21% oxygen and 1% carbon dioxide and other gases.
Volume of oxygen in 50 cm^3 of air
$= \frac{21}{100} \times 50\ cm^3$
$= 10.5\ cm^3$ (approximately 10 cm^3)

Must-Know Concept:
Percentage composition of atmospheric air

8. **D**
'Acid rain' is formed by acidic air pollutants. Carbon monoxide is a neutral oxide and will not dissolve in rain to form 'acid rain'.

Must-Know Concept:
Sources of pollutants and their effects on the environment

9. **A**
Fossil fuels such as coal and petroleum contain sulfur. When sulfur compounds are burnt, sulfur dioxide is produced. The sulfur dioxide formed is acidic and reacts with water in the atmosphere to form acid rain. Hence, statement 1 is correct and statement 2 explains statement 1.

Must-Know Concept:
Sources of sulfur dioxide and its effect on the environment

10. **B**
Air contains 78% nitrogen, 21% oxygen and 1% other gases which contain noble gases, carbon dioxide and water vapour. Alkaline pyrogallol absorbs oxygen and carbon dioxide, and anhydrous calcium chloride absorbs water vapour as air passes through, leaving argon and nitrogen at the end of the apparatus. Hydrogen is not present in atmospheric air.

Must-Know Concept:
Composition of gases in air mixture

11. **C**
Air is a mixture that contains 21% of oxygen.
Approximately $\frac{1}{5}$ of air is oxygen,
50 cm^3 of air $\times \frac{1}{5} = 10\ cm^3$ of oxygen.

Must-Know Concept:
Composition of oxygen in air mixture

12. **D**
Clean, dry air contains 78% nitrogen, 21% oxygen, 0.97% noble gases (mostly argon) and 0.03% carbon dioxide.

Must-Know Concept:
Composition by volume of gases present in dry air

13. **D**
For the limestone buildings to begin crumbling, the limestone must have undergone some chemical reactions with an acid / acidic substance(s) from the surroundings such as acid rain. The steel and chemical factories nearby have released sulfur dioxide into the air, which then reacted with water in the atmosphere, forming acid rain. Acid rain has corrosive effect on limestone.

Must-Know Concept:
Effects of air pollutants on the environment

14. **B**
Carbon monoxide, nitrogen oxide and ozone are atmospheric pollutants.

Must-Know Concept:
The types of atmospheric pollutants

15. **C**
Air consists of 78% nitrogen. $\frac{78}{100} \times 50 = 39\ cm^3$

Must-Know Concept:
Air consists of 78% nitrogen.

Paper 4
Section A

1. (a) **B** is oxygen.
C is nitrogen.
(b) Gas 1: Sulfur dioxide
Source: Volcanic eruption
Gas 2: Carbon monoxide
Source: Incomplete combustion of carbon compounds
(Accept any possible answers)

2. (a) Oxygen
(b) Nitrogen monoxide (or any oxides of nitrogen) / Carbon monoxide
(Any one)
(c) Methane

3. oxygen = 21 %
nitrogen = 78 %

4. (a) (i)

gas	source
carbon monoxide	**Incomplete combustion of carbon-containing substances**
nitrogen oxides	**Burning of fuels in internal combustion engines / Lightning activities** *(Any one)*
sulfur dioxide	**Burning of fossil fuels / Volcanic activities** *(Any one)*

(ii) Methane / Unburnt hydrocarbons / Ozone (*Any one*)
(b) (i) sulfur dioxide + water → sulfurous acid
(ii) effect on statue: The statue will become corroded and defaced.
explanation: Marble is made of calcium carbonate which will react with the acid rain to form salt, water and carbon dioxide.

Section B

1. In the car engine, there is a limited supply of air which results in incomplete combustion of the fuel to form carbon monoxide.

TOPIC 8 Fuels and Crude Oil, Alkanes and Alkenes

Paper 3

1. **D**
Bitumen is used to make roads and it is collected at the bottom of the fractionating column.

Must-Know Concept:
Arrangement of fractions obtained from the fractional distillation of crude oil according to their boiling points and their uses

2. **C**
All three substances in option C belong to the alkene group. They are categorised as unsaturated hydrocarbons with the general formula C_nH_{2n} and contain a C=C bond.

Must-Know Concept:
Identification of functional group from given molecular structures, definition of a homologous series

3. **D**
Cracking is the breakdown of large molecules of alkanes into more useful, smaller alkenes, alkanes and/or hydrogen. The number of carbon and hydrogen atoms must be the same on both sides of the equation.

Must-Know Concept:
Definition of cracking

4. **B**
Methane is an alkane. Alkanes undergo complete combustion to form carbon dioxide and water.

Must-Know Concept:
Products formed by complete combustion of alkane

5. **A**
An homologous series is a family of organic compounds with the same general formula.

Must-Know Concept:
Properties of a homologous series

6. **C**
The formula of compound **X** shows the presence of a C=C bond, which indicates it to be an alkene (unsaturated compound). Addition of aqueous bromine to alkenes would cause a colour change from brown to colourless.

Must-Know Concept:
Identification of type of compound based on a given structural formula, bromination reaction of alkene

7. **A**
The diagram shows a fractionating column. The process is the fractional distillation of crude oil. Substance M is distilled as one of the middle fractions. It is kerosene (paraffin) and it is used as fuel for aircrafts.

Must-Know Concept:
Arrangement of fractions obtained from the fractional distillation of crude oil according to their boiling points and their uses

8. **B**
Hydrocarbons 1 and 3 may be from the same homologous series because they have the same reactions of combusting with oxygen and decolourising aqueous bromine. Members belonging to the same homologous series will have similar chemical reactions due to them possessing the same functional group.

Must-Know Concept:
Properties of a homologous series

9. **C**
An unsaturated hydrocarbon contains a C=C bond. Only the structure in option C contains a C=C bond.

Must-Know Concept:
Identification of functional group from given molecular structures

10. **B**
The molecules in food are made up of carbohydrates, proteins and fats. These molecules contain hydrogen, carbon, oxygen and nitrogen so they are not hydrocarbons, which only contain carbon and hydrogen atoms. An unsaturated molecule is a molecule that contains carbon to carbon double bonds.

Must-Know Concept:
Definition of polyunsaturated

11. **C**
J does not contain any carbon to carbon double bond (C=C). Hence, it is a saturated compound. J is not a hydrocarbon because it contains an oxygen atom.

Must-Know Concept:
Definition of saturated hydrocarbon

12. **C**
The carbon to carbon double bond of an alkene enables it to react with bromine. In the process, the colour of aqueous bromine changes from brown to colourless. Alkanes do not contain carbon to carbon double bonds.

Must-Know Concept:
Bromination reaction of alkene

13. **C**
Petroleum consists of a mixture of hydrocarbons in the liquid state. Methane is an example of a hydrocarbon.

Must-Know Concept:
Definitions of mixture and hydrocarbon

14. **A**
A polyunsaturated molecule consists of multiple double bonds. Hydrogen has only one valence electron. It is impossible for hydrogen to form a double bond with carbon.

Must-Know Concept:
Definition of polyunsaturated

15. **C**
Option C shows the structure of ethene. Ethene has a double bond and undergoes addition reaction with bromine and the bromine solution decolourises.

Must-Know Concept:
Bromination reaction of alkene

16. **B**
A hydrocarbon that burns completely produces carbon dioxide and water vapour. Carbon monoxide is produced from the incomplete combustion of hydrocarbons.

Must-Know Concept:
Products formed by incomplete and complete combustions of alkene

17. **C**
Natural gas consists of methane as its main component.

Must-Know Concept:
Major component of natural gas

18. **B**
The difference between one member and the next in the homologous series shown is the methylene bridge, CH_2, which is the backbone of the unbranched alkanes as shown.

Must-Know Concept:
General formula of alkane

19. **B**
Cracking is the process of breaking down long-chain hydrocarbons into short ones by passing the long-chain hydrocarbons over a catalyst at high temperatures.

Must-Know Concept:
Cracking of long-chain hydrocarbons

20. **A**
Margarine is manufactured via hydrogenation of vegetable oils into a solid. Hydrogenation is an example of an addition reaction whereby hydrogen adds across the double bonds leaving only single bonds.

Must-Know Concept:
Addition reaction between unsaturated fats and hydrogen gas (hydrogenation)

21. **A**
Compounds of the same homologous series obey the same general formula. The physical properties are dependent on the relative molecular mass while the relative molecular mass and structural formula are dependent on the number of carbon atoms present in the chemical formula.

Must-Know Concept:
Similarities of compounds in a homologous series

22. **B**
Flammability decreases as the number of carbon atoms increases. The size of molecules increases as the number of carbon atoms increases.

Must-Know Concept:
Trend of the physical properties of compounds in a homologous series of alkane

23. **A**
Vegetable oils are unsaturated fats which contain carbon-carbon double bonds. Hydrogen gas is added to vegetable oil in the presence of nickel to produce margarine.

Must-Know Concept:
The conditions required for the production of margarine

24. **C**
The following fractions and their uses must be recalled—petroleum gas as fuel for cooking, petrol/gasoline as fuel in cars, naphtha as the feedstock for the petrochemical industry, paraffin (kerosene) as fuel for aircraft engines, diesel as fuel for diesel engines in heavy vehicles, lubricating oil as lubricants and sources of polishes and waxes, and bitumen for making road surfaces.

Must-Know Concept:
The order of the various petroleum fractions obtained through fractional distillation in the fractionating column and their specific uses

25. **D**
The reaction between ethene and bromine is called bromination, the addition of bromine.

ethene bromine 1,2-dibromoethane

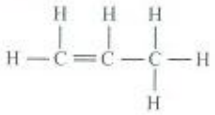
Must-Know Concept:
Addition reactions of alkenes using ethene

26. **D**
Natural gas consists primarily of methane.

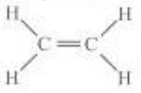
Must-Know Concept:
The main constituent of natural gas

Paper 4
Section A

1. (a) (i) **H**
(ii) Methane / Ethane / Propane *(Any one)*
(b) (i) C_7H_{16}
(ii)



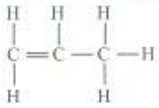
2. (a) Fractional distillation
(b) (i) Cracking
(ii) Propene
(iii)



3. **P** and **S**
Q and **R**
Q and **R**

Explanation:
A hydrocarbon is saturated when it contains only carbon-carbon single covalent bonds. Alkenes are unsaturated hydrocarbons and undergo addition reactions with bromine, hydrogen and steam.

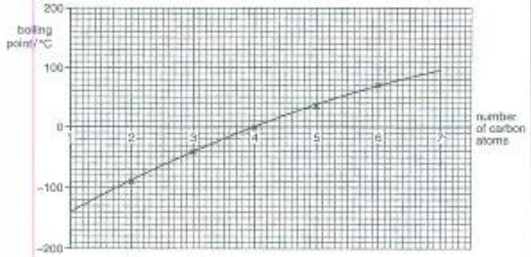
4. (a) cracking
(b) name of C_2H_4: ethene
name of C_3H_6: propene
(c)



Section B

1. (a) (i) A saturated hydrocarbon is one in which all carbon-carbon bonds are single bonds while an unsaturated hydrocarbon is one in which at least one carbon-carbon bond is a double bond.
(ii) reagent: Aqueous bromine
observation with ethane: The brown solution remains unchanged.
observation with ethene: The brown solution turns colourless.

(b) (i)

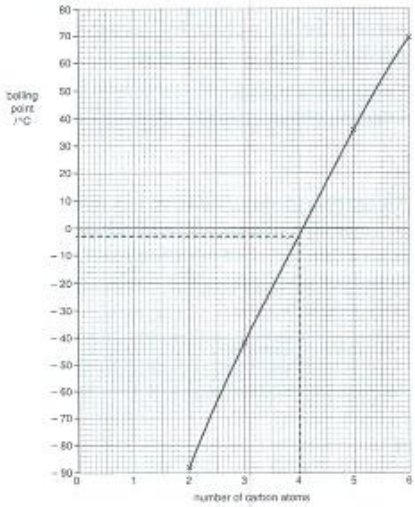


(ii) 95°C

2. (a) (i) Boiling point
(ii) Kerosene and naphtha
(Accept any possible answers)
(b) (i) Cracking
(ii) It acts as a catalyst to speed up the reaction.
(iii) C_8H_{18}
(iv)

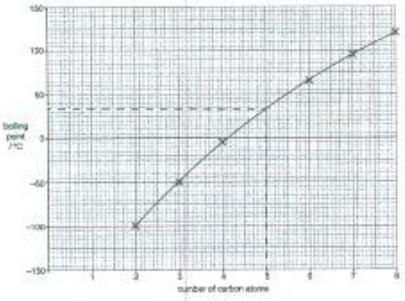
(c) (i) It contains two or more C=C bonds.
(ii) Hydrogenation / Addition of hydrogen

3. (a) (i) C_nH_{2n+2}
(ii) $C_{10}H_{22}$
(b) (i) Substitution reaction
(ii) $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$
(c) (i)



(ii) Boiling point of butane = –3°C
(Accept answers that are ±1°C)
(d) Cracking

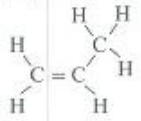
4. (a) (i) Hydrocarbon is an organic compound which contains hydrogen and carbon atoms only.
(ii) 1. Down the homologous series, the melting and boiling points increase.
2. Down the homologous series, the flammability of the organic compounds decreases.
(b) (i) C_nH_{2n}
(ii)



(iii) 33°C
(iv) The boiling point increases when the number of carbon atoms increases.

5. (a) Aqueous
(b) The reddish-brown solution turns colourless.
(c) Addition reaction

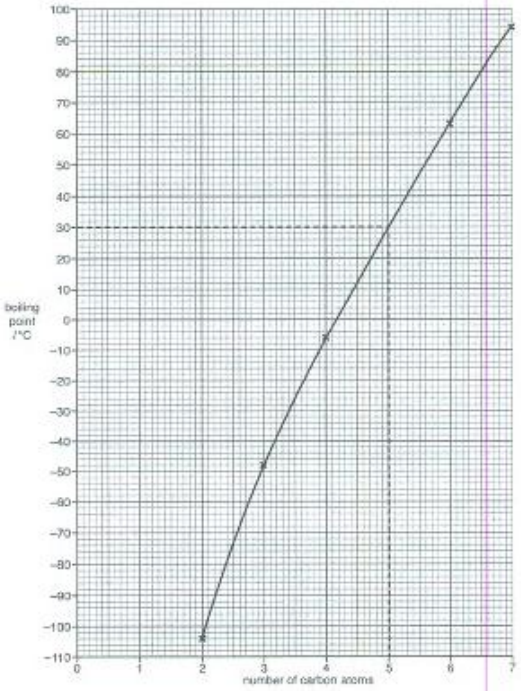
6. (a) Different boiling points
(b) (i) Water
(ii) liquid **Y**: Limewater / Calcium hydroxide
description: A white precipitate will be formed in the liquid.
(iii) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
(c) 1. Presence of catalyst (Al_2O_3/SiO_2)
2. High temperature (600°C)
(d) (i) $C_{12}H_{26} \rightarrow 4C_3H_6 + H_2$
$C_{12}H_{26} \rightarrow 3C_3H_6 + C_3H_8$
$C_{12}H_{26} \rightarrow 2C_3H_6 + C_6H_{14}$
$C_{12}H_{26} \rightarrow C_3H_6 + C_9H_{20}$
(*Any one*)
(ii)



7. (a) liquid
(b) C_nH_{2n+2}
(c) $C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$
(d) (i) Polyunsaturated means that the vegetable oils contain many carbon-carbon double bonds.
(ii) hydrogen
Explanation:
Margarine is manufactured by the addition of hydrogen to vegetable oils. A catalyst is used to speed up the reaction. The carbon-carbon double bonds in vegetable oils are converted into single bonds.

8. (a) (i) C_nH_{2n}
(ii) Each successive member differs by a $-CH_2$ group.
The M_r of each successive member differs by 14.
Melting point / Boiling point / Viscosity increases as the number of carbon atoms increases.
Flammability decreases as the number of carbon atoms increases.
(*Any two*)

(iii) Brown bromine water decolourises/ turns colourless.
(iv) $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$
(b) (i) and (ii)



(iii) 30

N(A) Level Science (Chemistry) September/October 2020 Examination Paper

Paper 3

1. **D**
Paper chromatography can be used to separate components (in this case, red and blue dyes) in a mixture (purple ink).

Must-Know Concept:
Separating mixtures using paper chromatography

5. (a) Low melting point / low density / soft
(*Any two*)

(b) $2Na + 2H_2O \rightarrow 2NaOH + H_2$

(c) Sodium is highly reactive and needs to be stored in an inert environment so that it will not react with water or oxygen.

(d) (i) most reactive: **S**
T
Q
least reactive: **R**

(ii) gas: hydrogen
test: Hydrogen extinguishes a lighted splint with a 'pop' sound.

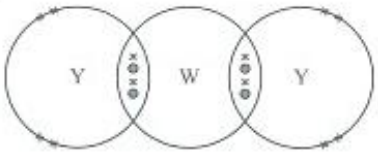
(e) alloy

6. (a) (i) 7

(ii) particles: **W** and **X**
explanation: **W** and **X** have the same number of protons which is 6 but **W** has 6 neutrons while **X** has 8 neutrons.

(iii) particles: **V** and **Z**

(iv)



× : electron of Y
⊙ : electron of W

(b) (i) 80°C: liquid
70°C: liquid
60°C: solid

(ii) The molecules lose kinetic energy and move closer together. They slide past one another slower.

Weightage of marks by topic

The table below shows the distribution of marks by topics for each paper. The highlighted figures denote the topics that are of significant weightage in the respective papers. The total marks for Paper 3 (P3) is 20, Paper 4 Section A (P4 A) is 14 and Paper 4 Section B (P4 B) is 16.

Topic	Weightage (by marks)																	
	2016			2017			2018			2019			2020			Average		
	P3	P4 A	P4 B	P3	P4 A	P4 B	P3	P4 A	P4 B	P3	P4 A	P4 B	P3	P4 A	P4 B	P3	P4 A	P4 B
Experimental Design, Methods of Purification and Analysis and Identification of Gases	10.0%	14.3%	31.3%	10.0%	–	–	15.0%	42.9%	12.5%	5.0%	–	–	5.0%	64.3%	–	9.0%	24.3%	8.8%
Kinetic Particle Theory	5.0%	–	–	–	–	–	–	–	25.0%	5.0%	–	–	5.0%	–	12.5%	3.0%	–	7.5%
Atomic Structure	5.0%	21.4%	–	5.0%	–	–	5.0%	14.3%	–	5.0%	21.4%	–	5.0%	–	37.5%	5.0%	11.4%	7.5%
Structure and Properties of Materials, Ionic Bonding and Covalent Bonding	10.0%	35.7%	–	15.0%	–	12.5%	5.0%	14.3%	12.5%	10.0%	14.3%	–	10.0%	–	–	10.0%	12.9%	5.0%
Formulae and the Mole Concept	5.0%	–	18.8%	5.0%	21.4%	–	10.0%	–	25.0%	10.0%	7.1%	–	5.0%	14.3%	–	7.0%	8.6%	8.8%
Acids, Bases and Salts	10.0%	–	–	10.0%	14.3%	50.0%	10.0%	–	37.5%	10.0%	57.1%	50.0%	15.0%	–	–	11.0%	14.3%	27.5%
The Periodic Table: Periodic Trends and Group Properties	10.0%	–	25.0%	10.0%	21.4%	18.8%	10.0%	–	–	10.0%	–	18.8%	10.0%	21.4%	25.0%	10.0%	8.6%	17.5%
Properties of Metals, Reactivity Series, Extraction of Metals, Recycling of Metals and Iron	15.0%	–	75.0%	20.0%	–	–	20.0%	–	–	20.0%	–	31.3%	20.0%	–	25.0%	19.0%	–	26.3%
Air	5.0%	7.1%	–	10.0%	42.9%	–	10.0%	–	–	10.0%	–	–	10.0%	–	–	9.0%	10.0%	–
Fuels and Crude Oil, Alkanes and Alkenes	25.0%	21.4%	–	15.0%	–	68.8%	15.0%	28.6%	37.5%	15.0%	–	50.0%	15.0%	–	50.0%	17.0%	10.0%	41.3%