Answers for 3EXP Chem EYE P1 2023

1.	B	**11.**	C	**21.**	A	**31.**	D
2.	B	**12.**	C	**22.**	C	**32.**	D
3.	C	**13.**	B	**23.**	C	**33.**	B
4.	A	**14.**	A	**24.**	C	**34.**	D
5.	C	**15.**	B	**25.**	C	**35.**	C
6.	D	**16.**	A	**26.**	B	**36.**	D
7.	D	**17.**	A	**27.**	B	**37.**	B
8.	A	**18.**	B	**28.**	A	**38.**	A
9.	A	**19.**	D	**29.**	C	**39.**	C
10.	D	**20.**	D	**30.**	A	**40.**	C

Qn	Ans	Explanation
1.	B	22.15 cm^3 is accurate to 2 decimal places. Burette should be used as it can record up to 2dp (nearest 0.05 cm^3). Beaker measures approximate volumes. Measuring cylinder measures to the nearest 0.5 cm^3. Pipette is only accurate for fixed volumes up to 1dp.
2.	B	Concentrated sulfuric acid is used to dry acidic gases like sulfur dioxide.
3.	C	The apparatus shown is for the upward delivery gas collection method. Gas **X** must be less dense than air to be collected by an inverted gas jar. There is not enough information to deduce the solubility of gas **X**.
4.	A	Since solid **Y** is insoluble in ethanol, filtration can be used to easily separate them. The boiling points given are distractors.
5.	C	The diagram shows that the entire starting line has dissolved in the solvent and travelled up the chromatogram. This means that Megan did not use a pencil (which is insoluble in water) but instead used a pen (containing ink which is soluble in water).

6.	**D**	$R_f = \frac{7}{13}$ $= 0.538$
7.	**D**	Substance **Z** is a solid at 179 ºC and a gas at 232 ºC. For option D, substance **Z** will change from solid to liquid state at 194 ºC and change from liquid to gaseous state at 229 ºC.
8.	**A**	Protons and neutrons are found in the nucleus of an atom while electrons are found in the electron shells around the nucleus.
9.	**A**	**I** is correct as the innermost shell can only contain two electrons. **II** is incorrect as the second shell can contain up to eight electrons. **III** is incorrect as the electron pairs can be placed at any of the four sides of the atom. **IV** is incorrect as the electronic structure shown is for an **ATOM** of **J**, not an ion. The valence shell of atoms are not always fully-filled.
10.	**D**	From the chemical formula **X**O, we know that the two ions in this ionic compound are X^{2+} and O^{2-}. Electrons are negatively charged. To form an oxide ion of 2- charge, oxygen atom must gain 2 electrons from an atom of **X**. Similarly, for **X** to become X^{2+} ion, each atom of **X** must lose 2 electrons.
11.	**C**	In **A**, F^- has 10 electrons, Cl^- has 18 electrons, and Br^- has 36 electrons. In **B**, H^+ has 0 electrons, He has 2 electrons, and N^{3-} has 10 electrons. In **C**, K^+ has 18 electrons, Ca^{2+} has 18 electrons, and P^{3-} has 18 electrons. In **D**, Na^+ has 10 electrons, Mg^{2+} has 10 electrons, and S^{2-} has 18 electrons.
12.	**C**	Each oxygen atom contains 6 valence electrons. 2 of these are used for bonding with sulfur and 4 are not. Therefore, electrons not used for bonding = 4 + 2 **inner shell** electrons = 6
13.	**B**	Covalent bonds are formed between non-metallic elements. Metals and non-metals form ionic bonds.

	metal	**non-metal**	**bonding**
A	calcium	bromine	ionic
B	-	phosphorus oxygen	covalent
C	strontium	sulfur	ionic
D	zinc	chlorine	ionic

14.	**A**	In metallic bonding, metal atoms lose their valence electrons to form positive metal ions. The valence electrons which are lost form the 'sea of delocalised electrons'. The forces of attraction between oppositely charged particles is electrostatic.
15.	**B**	Circles of the same size and colour represent the same element. A compound is represented by 2 or more different circles combined together (touching each other). **A**: one compound **B**: a mixture of an element and a compound **C**: a mixture of two different elements **D**: an element
16.	**A**	Potassium oxide is an ionic compound. Ionic compounds are hard and brittle.
17.	**A**	Lithium bromide is an ionic compound. An ionic compound exists as a giant ionic crystal lattice structure. The 3D arrangement should consist of positive and negative ions held together by electrostatic forces of attraction.
18.	**B**	Each carbon atom is only bonded to 3 other carbon atoms, leaving one unbonded valence electron to be delocalised. Hence, there are delocalised electrons that can act as mobile charge carriers to conduct electricity. **A**: carbon ions are not formed **C**: wrong concept **D**: strong covalent bonds exist between carbon atoms
19.	**D**	The chemical formula consists of two units of CH_3CNOH. Hence, in total, there are 4 carbon atoms, 8 hydrogen atoms, 2 nitrogen atoms and 2 oxygen atoms. So, in total, 16 atoms.
20.	**D**	From the formula $Ir_2(SO_4)_3$, we can deduce that the ions are Ir^{3+} and SO_4^{2-}. From the formula $Zn(ClO)_2$, we can deduce that the ions are Zn^{2+} and ClO^-. Therefore, the formula formed between Ir^{3+} and ClO^- is $Ir(ClO)_3$.
21.	**A**	B: the formula of magnesium chloride should be $MgCl_2$ C: equation is not balanced. LHS has 2 NO_3^- groups but RHS only has 1. D: the formula of potassium sulfate should be K_2SO_4
22.	**C**	Electronic configuration of the ion of E = 2.8 (after gaining 3 electrons) Electronic configuration of the ion of G = 2.8 (after losing 2 electrons) So the ions are E^{3-} and G^{2+}.
23.	**C**	There are 3 Hg on the RHS of the equation. Hence, there should be 3 Hg on the LHS as well. Thus, ***w*** = 3 and ***y*** = 1. The values for ***w***, ***x*** and ***y*** in option D will also work, but ***z*** is wrong as the number of H and O are not balanced.

<table>
<tr><td>24.</td><td>C</td><td>
<table>
<tr><td></td><td>percentage</td></tr>
<tr><td>A</td><td>$\frac{3(14)}{27+3(14)+9(16)} \times 100 = 19.7\%$</td></tr>
<tr><td>B</td><td>$\frac{2(14)}{3(24)+2(14)} \times 100 = 28\%$</td></tr>
<tr><td>C</td><td>$\frac{14}{14+16} \times 100 = 46.7\%$</td></tr>
<tr><td>D</td><td>$\frac{14}{14+2(16)} \times 100 = 30.4\%$</td></tr>
</table>
</td></tr>
<tr><td>25.</td><td>C</td><td>All the substances in this reaction are gases so we can use volume ratio directly instead of using mole ratio. 15 cm^3 of nitrogen (N_2) will react with 45 cm^3 of hydrogen (H_2). Since there is 60 cm^3 of hydrogen, hydrogen is in excess, and nitrogen is the limiting reagent.
After 45 cm^3 of hydrogen has reacted with nitrogen, 15 cm^3 of hydrogen is left. 30 cm^3 of ammonia (NH_3) was produced.
Hence, the total volume of gas remaining in the container is 15 + 30 = 45 cm^3.</td></tr>
<tr><td>26.</td><td>B</td><td>$\frac{68.54}{100} \times 63 + \frac{29.51}{100} \times 65 + \frac{1.95}{100} \times 67 = 63.6682$
$= 63.67$</td></tr>
<tr><td>27.</td><td>B</td><td>
<table>
<tr><td></td><td>carbon</td><td>hydrogen</td></tr>
<tr><td>mass</td><td>4.8</td><td>0.8</td></tr>
<tr><td>A_r</td><td>12</td><td>1</td></tr>
<tr><td>mass ÷ A_r</td><td>0.4</td><td>0.8</td></tr>
<tr><td>simplest ratio</td><td>$\frac{0.4}{0.4} = 1$</td><td>$\frac{0.8}{0.4} = 2$</td></tr>
</table>

∴ empirical formula = CH_2</td></tr>
<tr><td>28.</td><td>A</td><td>$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

no. of moles of CO_2 = 3.0 ÷ 24
= 0.125 mol

no. of moles of CO_2 : Na_2CO_3 = 1 : 1
no. of moles of Na_2CO_3 = 0.125 mol</td></tr>
</table>

		mass of Na_2CO_3 that reacted with HCl = 0.125 × 106 = 13.25 g percentage purity = $\frac{13.25}{53} \times 100$ = 25%
29.	**C**	Amphoteric oxides that we have learnt are zinc oxide, aluminium oxide and lead(II) oxide. Metal oxides are basic while non-metal oxides are acidic.
30.	**A**	Calcium hydroxide is the chemical commonly used to neutralise acidity in soil, increasing the pH. Sodium hydroxide is an alkali that is too strong to be used.
31.	**D**	H^+ ions are responsible for the acidic properties of acids.
32.	**D**	Since lead(II) sulfate is an insoluble salt, the **precipitation** method should be used. Hence, **two aqueous solutions** should be selected in preparing this salt. In option D, lead(II) nitrate and sodium sulfate are both soluble in water and can form aqueous solutions. In option A, lead metal and sulfuric acid will react, but an insoluble layer of lead(II) sulfate will be formed on the metal surface, hence stopping the reaction. This results in some lead metal not being able to react with sulfuric acid. In option B, lead(II) carbonate will react with sulfuric acid, but the same scenario in option A will happen too. In option C, both lead(II) chloride and barium sulfate are insoluble salts. Hence, when they are mixed together, both solids will not react with each other.
33.	**B**	In salt preparation, we usually want to obtain pure samples of the salt formed. The addition of a foreign substance, like the indicator, to the reaction mixture will contaminate the products formed. Hence, once the volume to be added is determined with the use of an indicator, the experiment is repeated without adding the indicator.
34.	**D**	Option A is to test for oxygen. Option B is to test for chlorine. For Option C, we did not learn any gas that will turn blue and is then bleached. However, sulfur dioxide is an acidic gas and will not turn red litmus paper blue.
35.	**C**	Upon adding aqueous sodium hydroxide, the green ppt formed indicates that iron(II) ions are present. Upon adding nitric acid, no effervescence observed indicates that carbonate ions are absent. Upon adding aqueous sodium hydroxide, aluminium foil and warming, the ammonia (pungent) gas evolved which turned moist red litmus paper blue indicates that nitrate ions are present. Hence, the cation is iron(II) and the anion is nitrate.
36.	**D**	The chart shows the number of electrons required to be gained/lost/shared in order for the atoms of the elements to form a fully-filled valence shell. This property is known as “valency”. For example, carbon needs to share 4 electrons while aluminium needs to lose 3 electrons.

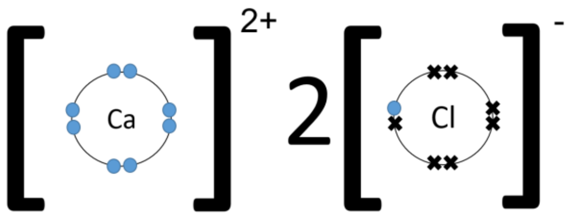
37.	**B**	Noble gases have a fully-filled valence electron shell and are thus very stable and inert (unreactive). Option A is wrong because they are colourless at room temperature. Option C is wrong because helium gas has a low density (can float in air!) Option D is wrong because helium has a duplet configuration (only 2 valence electrons).
38.	**A**	A more reactive halogen can displace a less reactive halogen from its halide solution. Hence, only halogens that are more reactive than bromine can displace it from sodium bromide. The reactivity of the halogens are: fluorine > chlorine > bromine > iodine > astatine. Thus, only fluorine and chlorine can displace bromine.
39.	**C**	The more reactive a metal is, the more difficult it is to decompose its carbonate by heat. Sodium carbonate and potassium carbonate are the highest in the reactivity series and they are unaffected by heat.
40.	**C**	Since H is the only metal that does not react with hydrochloric acid, it is the least reactive metal here. So, options B and D are wrong. G can be reduced by hydrogen (since steam is produced by the reaction), while I and J cannot be reduced by hydrogen. This means that G is less reactive than I and J. Therefore, the answer is option C. Double checking your answer, since metal I is able to displace J from the sulfate of J, metal I is more reactive than J. Thus, metal I is the most reactive metal.

Answers for 3EXP Chem EYE P2 2023

Section A				Remarks
A1	**(a)**	Al	[1]	There were a few students gave more than 1 element and even wrongly suggested the name of element rather than the formula.
	(b)	V	[1]	
	(c)	Na, K, Ca, or V	[1]	
	(d)	K	[1]	
	(e)	Ne	[1]	
	(f)	C	[1]	
	(g)	Br	[1]	
A2		Substance **A**. Its constituents have **<u>no fixed ratio</u>**. [1] Substance **A** contains a range of **<u>90.4 – 95.6%</u>** iron and **<u>4.4 – 9.6%</u>** carbon. [1] *(Note: students must quote data to score the 2nd mark)*	[2]	Most students failed to quote data in their answers and/or did not mention "fixed ratio".
A3	**(a)**	$2Fe_2O_3$ (s) + 3C (s) → 4Fe (s) + $3CO_2$ (g) [1] correct formulae and balanced equation [1] state symbols (only award this 1m if formulae are correct)	[2]	Many wrote the wrong formulae/ reactants/ products. Some gave carbon as a gas.
	(b)	Carbon dioxide is a greenhouse gas and contributes to global warming.	[1]	Contribution to global warming was hardly mentioned.

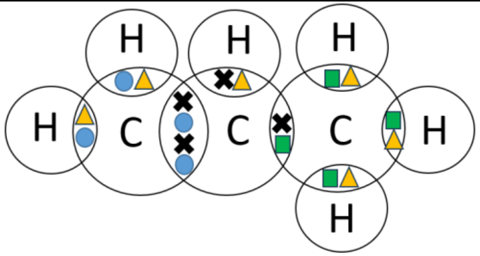
	(c)	She is **wrong** as iron **does not react** with cold **water**. [A] She is **wrong** as iron **reacts very slowly** with **water** in the **presence of air/oxygen**, in a process called rusting. *(note: chemical equation not required)*	[1]	Some mentioned iron(III) hydroxide should be obtained. Some said iron only reacts with steam but they are not answering the question.
A4	**(a)**	Gases **X** and **Y** have a **lower** relative **molecular mass** than oxygen. [1] The gases **diffuse faster** into the container filled with oxygen than the oxygen diffuses out of the container. [1] The gases are then pushed down the tube (due to higher pressure), into the water, and the gases escape as bubbles. [1] *(accept OWTTE)*	[3]	Some did not compare the speed of gases diffusing in AND out of the container.
	(b)	Carbon dioxide/ sulfur dioxide/ nitrogen dioxide/ fluorine/ argon/ hydrogen chloride *(accept other gases that have a higher M_r than oxygen)* [R] nitrogen, hydrogen, neon, ammonia	[1]	
	(c)	Chlorine has a **higher** relative **molecular mass** **than** the surrounding **air**. OR Chlorine has a **higher density** **than** the surrounding **air**. *(Note: comparison must be made with air)*	[1]	Some compared density with oxygen, which was unnecessary and does not answer the question.
	(d)	1. Bubbles would be produced **more rapidly/faster** in beakers of **gases X and Y**. [1] *(reject: more bubbles. The idea of speed must be there)* **OR** Water would rise **more rapidly/faster** up the tubes of **gas Z and chlorine**. [1] 2. As **temperature increases**, the **rate of diffusion increases**. [1]	[3]	Students must mention the **location** of the bubbles being produced faster (gas X and Y) or water rising faster up the tubes (gas Z and chlorine). Many students wrote “more bubble”, which was rejected.

<table>
<tr><td></td><td></td><td>3. <u>More thermal energy is converted into kinetic energy</u> in the gas particles,
OR
The gas particles have <u>more/higher kinetic energy</u> at higher temperatures, allowing them to move and diffuse faster. [1]</td><td></td><td></td></tr>
<tr><td>A5</td><td>(a)</td><td><table>
<tr><td></td><td>relative mass</td><td>relative charge</td></tr>
<tr><td>proton</td><td>1</td><td>+1</td></tr>
<tr><td>neutron</td><td>1</td><td>0/ zero/ neutral</td></tr>
<tr><td>electron</td><td>$\frac{1}{1840}$</td><td>-1</td></tr>
</table>
[1] for every 3 correct blanks</td><td>[2]</td><td>A few students did not write a value for the relative charges, or had instead written the plus and minus signs at the back of the number.</td></tr>
<tr><td></td><td>(bi)</td><td>14</td><td>[1]</td><td></td></tr>
<tr><td></td><td>(bii)</td><td>2.8.3</td><td>[1]</td><td></td></tr>
<tr><td></td><td>(biii)</td><td>They are <u>isotopes</u>. They are <u>atoms</u> of the <u>same element</u> that have the <u>same proton (atomic) number but different numbers of neutrons</u>.</td><td>[1]</td><td>Better performing students quoted data in the table to support their answers. A few students did not mention isotopes in their answer.</td></tr>
</table>

A6	**(a)**	 [1] correct arrangement of electrons [1] correct charge and ratio of ions	[2]	
	(bi)	1. Calcium chloride is an ionic compound which has a **giant ionic crystal lattice structure** [1] 2. with **oppositely charged ions/ calcium cations and chloride anions/ Ca^{2+} ions and Cl^- ions** held together by **strong electrostatic forces of attraction**. [1] 3. Thus, a **large amount of energy** is needed to **overcome** the attractive forces. [1]	[3]	Some missed out key words in the structure. Some did not write which particles were held together by the strong electrostatic FOA.
	(bii)	1. Calcium ions have **higher charge/ greater charge/ twice the charge** as compared to potassium ions. [1] 2. Hence, the electrostatic **forces of attraction between calcium ions and chloride ions** are **stronger** than that **between potassium ions and chloride ions**. [1] 3. **More energy** is **required** to **overcome** these forces of attraction. [1]	[3]	Some talked about losing 2 valence electrons vs losing only 1, or the energy required to lose electrons. Some had stated the charges but did not compare them, e.g. 2+ vs 1+.
	(ci)	Allotrope(s). [1]	[1]	
	(cii)	Diamond. [1] Diamond has **high melting point of 3550 ºC and/or high boiling point of 4830 ºC**, **does not conduct electricity** and is **not soluble in water**. [1] *Note: "By referring to Table 5.1…" means students need to quote data from the table!*	[2]	Most students did not quote data from the table. Students need to quote ALL these properties as they are all properties of diamond.

	(ciii)	Potassium chloride can **<u>conduct electricity in only the molten/aqueous state</u>**, but **<u>not in the solid state</u>**, while carbon (diamond) **<u>cannot conduct electricity</u>**. [1] In **<u>solid state</u>**, **<u>ions</u>** in potassium chloride **<u>can only vibrate about their fixed positions</u>** and they are **<u>not mobile</u>**. They cannot act as mobile charge carriers. In **<u>molten/aqueous state</u>**, the strong electrostatic forces of attraction have been overcome and the **<u>ions are mobile</u>**. The ions can then act as mobile charge carriers. [1] Carbon (diamond) has a giant covalent structure where **<u>all valence electrons are used for covalent bonding</u>** [1] hence it has **<u>no mobile/delocalised electrons</u>**. Thus, there are no mobile charge carriers. [1] *[R] if student only mentioned "carbon has no mobile ions" with no mention of electrons* *[A] if student mentioned both "carbon has no mobile electrons and no mobile ions"*	[4]	Students are not clear which states conduct electricity. Common mistake: <u>atoms</u> are used for bonding, no <u>carbon atoms</u> to act as mobile charge carriers
A7	**(a)**	**P**: $BaSO_4$ / barium sulfate [1] **Q**: NH_3 / ammonia [1] **R**: $Zn(OH)_2$ / zinc hydroxide [1] **S**: $ZnCl_2$ / zinc chloride [1] **T**: CO_2 / carbon dioxide [1] **U**: $CaCO_3$ / calcium carbonate [1] *Note: mixture contains Zn^{2+}, SO_4^{2-} , NO_3^- , and CO_3^{2-}*	[6]	
	(b)	Any 2 of the following, [1] each: • $ZnSO_4$ / zinc sulfate • $Zn(NO_3)_2$ / zinc nitrate • $ZnCO_3$ / zinc carbonate	[2]	Some students might have thought that the mixture cannot contain 2 zinc salts.

A8	**(a)**	The particles are vibrating and rotating about their fixed positions. [1] They are very closely packed in an orderly manner. [1]	[2]	Many students missed out on “rotating”. Some students did not even answer the part on arrangement or left one part out.
	(b)	10 min *[R] if no units*	[1]	Common mistake: 8 min (students read the graph from 2 min to 10 min)
	(c)	The forces of attraction between the particles at point **B** is stronger than that at point **C**. [1] The kinetic energy of the particles at point **B** is lower than that at point **C**. [1]	[2]	
A9		no. of moles of $Ca_3(PO_4)_2$ = mass ÷ M_r = 100 ÷ [3(40) + 2(31 + 4 × 16)] = 100 ÷ 310 = 0.32258 mol (5sf) [1] no. of moles of $Ca_3(PO_4)_2$: $CaSiO_3$ = 2 : 6 = 1 : 3 no. of moles of $CaSiO_3$ = 0.32258 × 3 = 0.96774 mol [1] theoretical mass of $CaSiO_3$ produced = no. of moles × M_r = 0.96774 × (40 + 28 + 3 × 16) = 0.96774 × 116 = 112.2578 = 112.26 g [1] percentage yield of wollastonite = $\frac{actual\ mass}{theoretical\ mass} \times 100\%$ = $\frac{87\ g}{112.26\ g} \times 100\%$ = 77.5% (3sf) [1]	[4]	Common mistake: some students used the stoichiometric coefficient in the calculation of M_r

A10	**(ai)**	Fractional distillation. (*Reject: spelling errors)* R: Distillation	[1]	Common mistake: "distillation" or "simple distillation"
	(aii)	The components have a **<u>difference</u>** in their **<u>boiling points</u>**.	[1]	Some mentioned melting point, which is irrelevant
	(aiii)	No. The components are **<u>miscible</u>**/ **<u>can mix</u>**.	[1]	Some talked about density
	(bi)	A substance/compound that contains **<u>only hydrogen and carbon</u>**.	[1]	The word "only" is commonly missing.
	(bii)	 [1] one C=C double bond and one C-C single bond seen [1] correct arrangement of electrons and atoms *Accept if students used the same symbol for alternating C atoms (e.g. dot for carbon 1 and 3)* *Accept if students used different symbols from answer key, as long as different symbols are used to represent electrons*	[2]	Many used only single carbon-carbon bonds. Some exceeded 8 valence electrons for carbon
	(biii)	No. Propene is a simple covalent molecule/compound and **<u>does not have any mobile electrons/ mobile ions</u>** to act as mobile charge carriers to conduct electricity.	[1]	Many talked about how propene is not soluble because it's a covalent compound, but whether something conducts electricity depends on the mobile charge carrier. Those who mentioned dissolve to form ions did not mention "mobile".

	(biv)	$2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$	[1]	Some who have the correct reactants and products cannot balance the equation.
	(bv)	Check the melting/boiling point of propene. If it has a **fixed melting/boiling point**, it is **pure**. OR Check the melting/boiling point of propene. If it has a **range of melting/boiling point**, it is **impure**.	[1]	
	(c)	Any three of the following: • Some components of crude oil are **not soluble in the solvent** chosen as there is **still a spot left on the starting line**. [1] • Some components of crude oil have **similar Rf values/ do not separate well** in the solvent chosen. This can be seen from the **overlapping spots**. [1] • Propene, butane and propane are **pure** substances/compounds as they **produce only one spot**. [1] • Crude oil contains **at least** **4 components** as it produced **at least 4 spots**. [1] • Crude oil is **impure** as it produced **at least 4 spots**. [1] • Propane is **more soluble than propene and butane** as its **spot travelled a further distance/ is at a higher height** than the **spots of propene and butane**. [1] • Crude oil **contains propene** as the **spot in crude oil is at the same height as the propene's spot**. [1] • Crude oil **does not contain butane** as there is **no spot in crude oil that is at the same height as the butane's spot**. [1] *Note: Students need to state the conclusion AND give supporting evidence from Fig 9.2 to score each 1m.*	[3]	Badly done. Many students did not answer the question by quoting the supporting evidence from the diagram.

Section B				Remarks
B11	**(a)**	no. of moles of sulfuric acid = vol × conc = 0.025 × 0.40 = 0.01 mol [1] no. of moles of sulfuric acid : sodium hydroxide = 1 : 2 = 0.01 mol : 0.02 mol concentration of sodium hydroxide = no. of moles ÷ vol = 0.02 ÷ 0.035 = 0.57143 (5sf) = 0.571 mol/dm^3 (3sf) [1]	[2]	
	(b)	$H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$	[1]	
	(ci)	The <u>**colourless**</u> sodium sulfate solution <u>**turns green**</u>.	[1]	Students are expected to state the initial and final colour.
	(cii)	The concentration of H^+ and OH^- ions are <u>**equal**</u>.	[1]	Badly done. Many students mentioned that there are no more ions present and couldn't interpret that neutralisation is taking place.
	(d)	1. Using a <u>pipette</u>, transfer 25.0 cm^3 of dilute sodium hydroxide (aq) into a clean <u>conical flask</u>. 2. Add 1 – 2 drops of methyl orange indicator to aqueous sodium hydroxide. The solution <u>turns yellow</u>. 3. Fill a burette with dilute sulfuric acid. [1] Note the initial burette reading. 4. Release the acid into the conical flask slowly, swirling the conical flask at the same time. Continue until 1 drop of the acid turns the indicator from <u>yellow to orange</u>. [1] This is the end-point.	[5]	Underlined words are the commonly missed out words by students.

		5. Record the final burette reading and measure the volume of dilute sulfuric acid required ($V_2 – V_1$) cm^3 for complete neutralisation. [1] (Repeat) 6. **Pipette 25.0 cm^3 of dilute sodium hydroxide** into a conical flask without adding any indicator. 7. Add ($V_2 – V_1$) cm^3 of dilute sulfuric acid from the burette. [1] (From step 5) 8. **Heat** the solution until **saturated** and allow it to **cool** and **crystallise**. 9. **Filter** to obtain the crystals. **Wash** with **a little cold distilled water** to remove the impurities. 10. **Dry** the crystals with pieces of filter paper. [1]		
B12	**(a)**	$2HNO_3 + Mg \rightarrow Mg(NO_3)_2 + H_2$ no. of moles of nitric acid = vol × conc = 0.030 × 0.80 = 0.024 mol no. of moles of magnesium = mass ÷ A_r = 10 ÷ 24 = 0.41667 mol (5sf) [1] for determining no. of moles of nitric acid OR magnesium correctly Using no. of moles of nitric acid, 0.024 mol of nitric acid reacts with 0.012 mol of magnesium. Since there are 0.41667 mol of magnesium, magnesium is in excess and nitric acid is the limiting reagent. [1] *for determining limiting reagent* **OR** Using no. of moles of magnesium, 0.41667 mol of magnesium reacts with 0.83334 mol of nitric acid. Since there is only 0.024 mol of nitric acid, nitric acid is the limiting reagent. [1] *for determining limiting reagent*	[3]	Many did not determine the limiting reagent. Some did not leave the final answer in 3sf.

		no. of moles of nitric acid : magnesium nitrate = 2 : 1 = 0.024 mol : 0.012 mol mass of magnesium nitrate produced = no. of moles × M_r = 0.012 × [24 + 2(14 + 3 × 16)] = 0.012 × 148 = 1.776 = 1.78 g (3sf) [1]		
	(b)	**Insert a lighted splint** into the test gas/ at the mouth of the test tube. The lighted splint **extinguishes with a pop sound**. [1]	[1]	
	(c)	[1] Any of the following: • The reaction takes a **longer time** to complete. • Effervescence/Bubbles is/are produced at a **slower rate**. [R] *Less* effervescence/bubbles produced. (The comparison should be speed, not quantity) Ethanoic acid is a **weak acid** that only **partially ionises in water** to **produce a low concentration of H+ ions** as **compared** to the **same volume of nitric acid**. [1] OR Ethanoic acid is a **weak acid** that only **partially ionises in an aqueous solution/water** while nitric acid is a **strong acid** that **completely ionises in an aqueous solution/water.** [1]	[2]	Some students did not mention water or aqueous solution. The role of water in acidity is important.

	(d)	1. With constant stirring, add **excess magnesium** strips/powder into a beaker of dilute nitric acid **until no more effervescence is observed**. [1] 2. **Filter** to **remove** the **excess** unreacted **magnesium** as the residue. Collect the filtrate, magnesium nitrate solution. [1] 3. The filtrate is heated to evaporate off excess water. The solution is **heated until it is saturated**. 4. The saturated solution is allowed to **cool** and **crystallise** to form magnesium nitrate crystals. [1] 5. The magnesium nitrate crystals are **filtered** and recovered as residue in the filter paper. The crystals are **washed** with **a little cold distilled water** to remove impurities. **Dry** the crystals by pressing them between dry sheets of **filter paper** and left to dry. [1]	[4]	Some students did not filter the crystals after crystallisation. Some did not specify that only **a little** cold distilled water should be used (to prevent the crystals from dissolving back into the solution).

SECTION A [70 marks]

Answer **ALL** the questions in the spaces provided.

A1 Fig. 1.1 shows part of the Periodic Table.

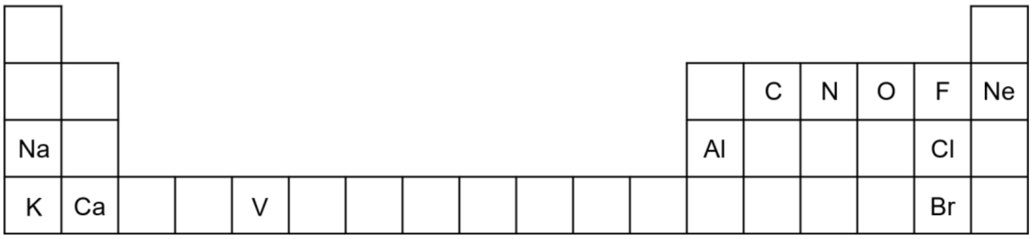


Fig. 1.1

Select elements from Fig. 1.1 to answer the following questions. You may use each element once, more than once or not at all.

Write down the atomic symbol for an element which

(a) has three electrons in its valence shell,
Al
.... [1]

(b) is metallic and forms coloured compounds,
V
.... [1]

(c) forms a basic oxide,
Na, K, Ca, or V
.... [1]

(d) has less than 20 protons and has four electron shells,
K
.... [1]

(e) is an inert gas,
Ne
.... [1]

(f) has a giant covalent structure,
C
.... [1]

(g) is a liquid at room temperature,
Br
.... [1]

[Total: 7]

A2 Table 2.1 shows the distribution of some elements in three substances.

Table 2.1

	element		
substance	oxygen	iron	carbon
A	0%	90.4 – 95.6%	4.4 – 9.6%
B	52%	48%	0%
C	66.7%	0%	33.3%

Identify and explain, using data from Table 2.1, which substance is a mixture.

Substance **A**. Its constituents have **no fixed ratio**. [1]
Substance **A** contains a range of **90.4 – 95.6%** iron and **4.4 – 9.6%** carbon. [1]

(Note: students must quote data to score the 2nd mark)

[2]

[Total: 2]

A3 Haematite, iron(III) oxide, is an iron ore that can be commonly found around the world.

(a) Haematite can be reduced with carbon to form two products. Write the balanced chemical equation, with state symbols, for this reaction.

$2Fe_2O_3\ (s) + 3C\ (s) \rightarrow 4Fe\ (s) + 3CO_2\ (g)$

[1] correct formulae and balanced equation
[1] state symbols (only award this 1m if formulae are correct) [2]

(b) The reaction in **(a)** is said to be non-environmentally friendly. Suggest a reason why.

Carbon dioxide is a greenhouse gas and contributes to global warming. [1]

(c) A student, Harini, commented, "Iron(III) oxide can also be obtained in the laboratory via the fast reaction between iron metal and water at 5 °C." Explain whether she is correct and write the chemical equation for the reaction that occurred, if any.

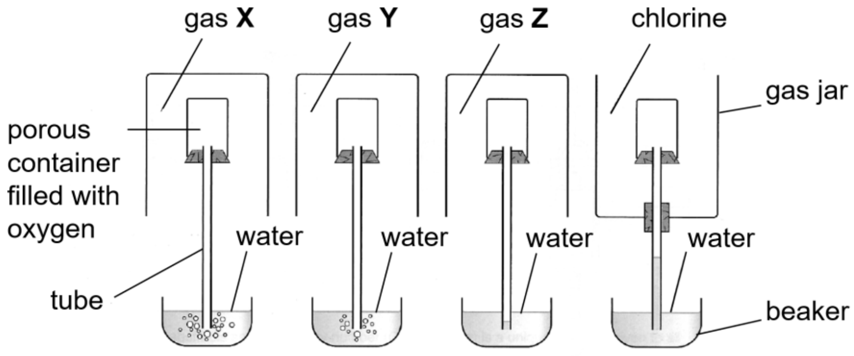
She is **wrong** as iron **does not react** with cold **water**.

[A] She is **wrong** as iron **reacts very slowly** with **water** in the **presence of air/oxygen**, in a process called rusting.
(note: chemical equation not required)

[1]

[Total: 4]

A4 A student conducted an experiment with the apparatus set-up below. Three unknown gases, **X**, **Y**, **Z** and chlorine gas are compared to oxygen gas. All the porous containers are filled with oxygen gas.



(a) Explain why bubbles are observed in the water for the set-ups containing gases **X** and **Y**.

Gases **X** and **Y** have a **lower** relative **molecular mass** than oxygen. [1]

The gases **diffuse faster** into the container filled with oxygen than the oxygen diffuses out of the container. [1]

The gases are then pushed down the tube (due to higher pressure), into the water, and the gases escape as bubbles. [1] *(accept OWTTE)*

[3]

(b) No bubbles were observed in the set-up containing gas **Z**. A small amount of water was seen to rise up the tube. Suggest a possible identity of gas **Z**.

Carbon dioxide/ sulfur dioxide/ nitrogen dioxide/ fluorine/ argon/ hydrogen chloride
(accept other gases that have a higher M_r than oxygen)

[R] nitrogen, hydrogen, neon, ammonia

[1]

(c) Suggest why the gas jar containing chlorine was arranged the opposite way from the other gas jars containing gases **X**, **Y** and **Z**.

Chlorine has a **higher** relative **molecular mass** **than** the surrounding **air**.
OR
Chlorine has a **higher density** **than** the surrounding **air**.

(Note: comparison must be made with air)

[1]

(d) The experiment was conducted at 25 °C. State and explain what would be observed if the experiment was conducted at 50 °C instead.

1. Bubbles would be produced **more rapidly/faster** in beakers of **gases X and Y**. [1]
   (reject: more bubbles. The idea of speed must be there)
   OR
   Water would rise **more rapidly/faster** up the tubes of **gas Z and chlorine**. [1]

2. As **temperature increases**, the **rate of diffusion increases**. [1]

3. **More thermal energy is converted into kinetic energy** in the gas particles,
   OR
   The gas particles have **more/higher kinetic energy** at higher temperatures,
   allowing them to move and diffuse faster. [1]

[3]

[Total: 8]

A5 **(a)** Table 4.1 describes the properties of some sub-atomic particles.

Complete Table 4.1.

Table 4.1

	relative mass	relative charge
proton	1	+1
neutron	1	0/ zero/ neutral
electron	$\frac{1}{1840}$	-1

[1] for every 3 correct blanks

[2]

(b) The symbol of an atom of aluminium is shown below.

$$^{27}_{13}Al$$

(i) State the number of neutrons it has.
14 [1]

(ii) Write the electronic configuration for this atom of aluminium.
2.8.3

[1]

(iii) The symbol for another atom of aluminium is $^{26}_{13}Al$.

State and explain the relationship between these two atoms of aluminium.

They are **isotopes**. They are **atoms** of the **same element** that have the **same proton (atomic) number but different numbers of neutrons**.

Note: Better performing students quoted data

[1]

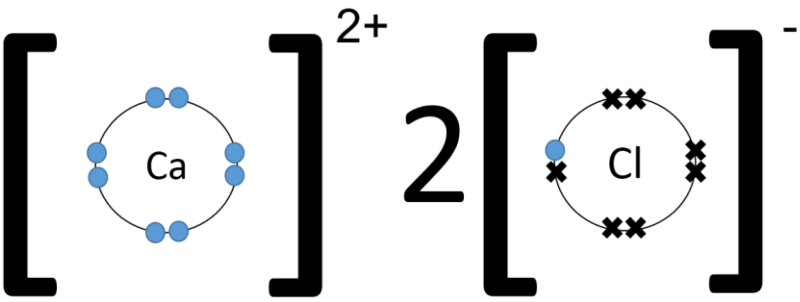
[Total: 5]

A6 A student, Yu Kai, was conducting an experiment to determine the physical properties of some substances. He recorded his results in Table 5.1 but accidentally spilled some water on a portion of his table.

Table 5.1

substance	melting point/ °C	boiling point/ °C	electrical conductivity	solubility in water
potassium chloride	770	1420		yes
calcium chloride	772	1935		yes
carbon	3550	4830	no	no

(a) Draw the 'dot-and-cross' diagram to show the bonding in calcium chloride. Show outer electrons only.



[1] correct arrangement of electrons
[1] correct charge and ratio of ions

[2]

(b) Calcium chloride has a melting point of 772 ºC.

(i) Explain calcium chloride's high melting point in terms of its structure and bonding.

1. Calcium chloride is an ionic compound which has a **giant ionic crystal lattice structure** [1]

2. with **oppositely charged ions/ calcium cations and chloride anions/ Ca^{2+} ions and Cl^- ions** held together by **strong electrostatic forces of attraction**. [1]

3. Thus, a **large amount of energy** is needed to **overcome** the attractive forces. [1]

[3]

(ii) Suggest and explain why calcium chloride has a higher melting point than potassium chloride.

1. Calcium ions have **higher charge/ greater charge/ twice the charge** as compared to potassium ions. [1]

2. Hence, the electrostatic **forces of attraction between calcium ions and chloride ions** are **stronger** than that **between potassium ions and chloride ions**. [1]

3. **More energy** is **required** to **overcome** these forces of attraction. [1]

[3]

(c) Carbon can exist in different forms with different structural arrangements of its atoms.

(i) State the term used to describe such different forms of carbon.

Allotrope(s).

[1]

(ii) By referring to Table 5.1, suggest and explain which form of carbon Yu Kai likely experimented on.

Diamond. [1]

Diamond has **high melting point of 3550 ºC and/or high boiling point of 4830 ºC**, **does not conduct electricity** and is **not soluble in water**. [1]

Note: "By referring to Table 5.1…" means students need to quote data from the table!

[2]

(iii) Compare the electrical conductivity between potassium chloride and this form of carbon. Explain your answer.

Potassium chloride can **conduct electricity in only the molten/aqueous state**, but **not in the solid state**, while carbon (diamond) **cannot conduct electricity**. [1]

In **solid state**, **ions** in potassium chloride **can only vibrate about their fixed positions** and they are **not mobile**. They cannot act as mobile charge carriers.
In **molten/aqueous state**, the strong electrostatic forces of attraction have been overcome and the **ions are mobile**. The ions can then act as mobile charge carriers. [1]

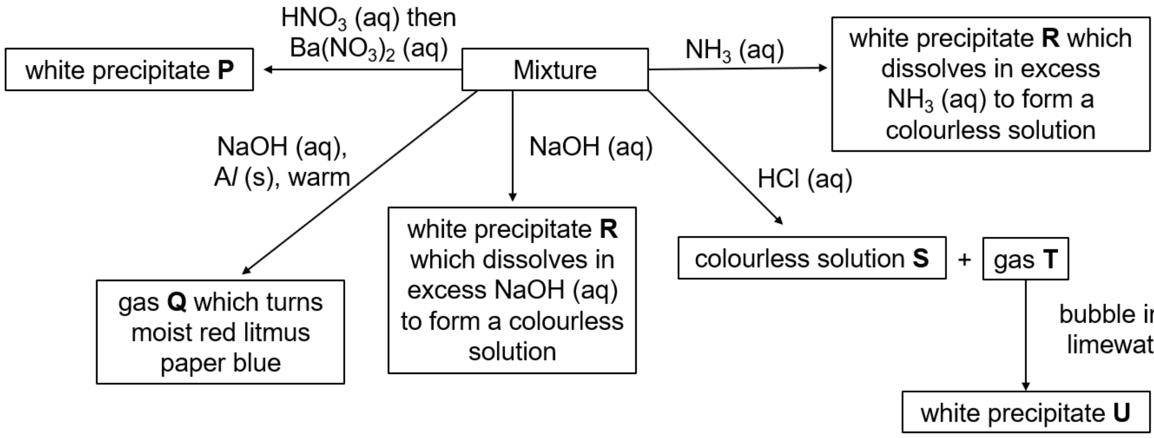
Carbon (diamond) has a giant covalent structure where **all valence electrons are used for covalent bonding** [1] hence it has **no mobile/delocalised electrons**. Thus, there are no mobile charge carriers. [1]

[R] if student only mentioned "carbon has no mobile ions" with no mention of electrons
[A] if student mentioned both "carbon has no mobile electrons and no mobile ions".

[4]

[Total: 15]

A7 The following reaction scheme describes some of the reaction carried out on an unknown mixture. This mixture contains three different salts.



(a) Identify the following substances.

P: $BaSO_4$ / barium sulfate [1]
Q: NH_3 / ammonia [1]
R: $Zn(OH)_2$ / zinc hydroxide [1]
S: $ZnCl_2$ / zinc chloride [1]
T: CO_2 / carbon dioxide [1]
U: $CaCO_3$ / calcium carbonate [1]

Note: mixture contains Zn^{2+}, SO_4^{2-} , NO_3^- , and CO_3^{2-}

[6]

(b) Suggest two of the salts that the mixture contains.

Any 2 of the following, [1] each:

- $ZnSO_4$ / zinc sulfate
- $Zn(NO_3)_2$ / zinc nitrate
- $ZnCO_3$ / zinc carbonate

[2]

[Total: 8]

A8 Fig. 7.1 shows the heating curve for a substance **X**.

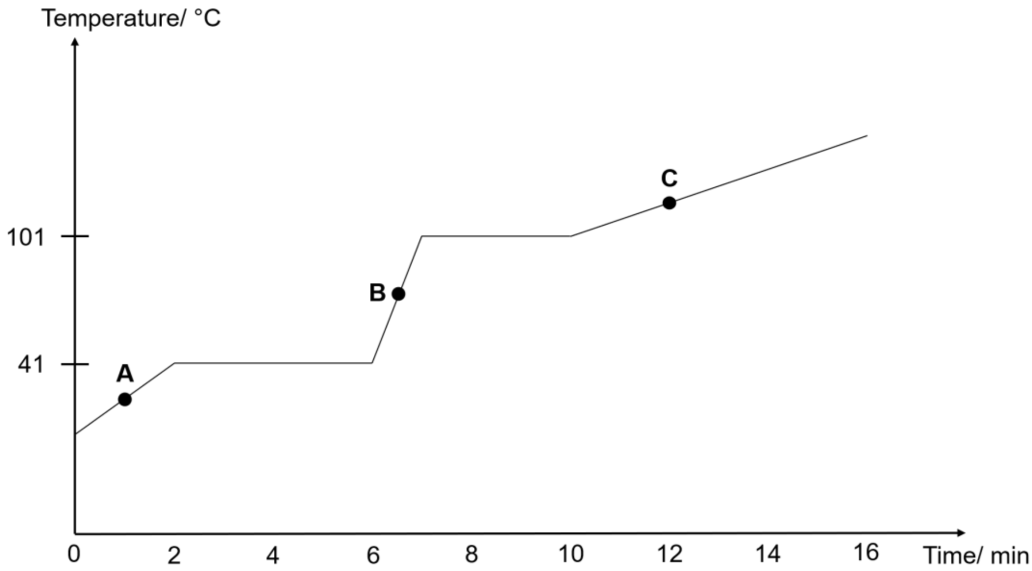


Fig. 7.1

(a) Describe, in terms of the kinetic particle theory, the movement and arrangement of the particles of substance **X** at point **A**.

The particles are vibrating and rotating about their fixed positions. [1]
They are very closely packed in an orderly manner. [1]

[2]

(b) State how long it took for substance **X** to completely change from a solid into a gas.

10 min
[R] if no units

[1]

(c) Compare the forces of attraction between the particles and the kinetic energy of the particles at point **B** and at point **C**.

The forces of attraction between the particles at point **B** is stronger than that at point **C**. [1]

The kinetic energy of the particles at point **B** is lower than that at point **C**. [1]

[2]

[Total: 5]

A9 Wollastonite, $CaSiO_3$, can be produced from the reaction between calcium phosphate and silicon dioxide.

$$2Ca_3(PO_4)_2 + 6SiO_2 \rightarrow P_4O_{10} + 6CaSiO_3$$

100 g of calcium phosphate, $Ca_3(PO_4)_2$, was used in this reaction. The actual mass of wollastonite produced was 87 g.

Calculate the percentage yield of wollastonite.

no. of moles of $Ca_3(PO_4)_2$ = mass ÷ M_r
= 100 ÷ [3(40) + 2(31 + 4 × 16)]
= 100 ÷ 310
= 0.32258 mol (5sf) [1]

no. of moles of $Ca_3(PO_4)_2$: $CaSiO_3$ = 2 : 6
= 1 : 3
no. of moles of $CaSiO_3$ = 0.32258 × 3
= 0.96774 mol [1]

theoretical mass of $CaSiO_3$ produced = no. of moles × M_r
= 0.96774 × (40 + 28 + 3 × 16)
= 0.96774 × 116
= 112.2578
= 112.26 g [1]

percentage yield of wollastonite = $\frac{actual\ mass}{theoretical\ mass} \times 100\%$
= $\frac{87\ g}{112.26\ g} \times 100\%$
= 77.5% (3sf) [1]

[4]

[Total: 4]

A10 Separation of crude oil for everyday use

How crude oil is separated

Crude oil is a naturally occurring viscous black oil. The raw material is made up of complex organic hydrocarbon structures and is formed from living matter that existed many millions of years ago. In that time, that matter has been processed by geological forces to create its current form of black oil. While it is sometimes found at surface level, crude oil is mostly obtained by drilling for oil in the ground at oil wells on land, and at oil rigs at sea.

In oil industries, crude oil can be separated to obtain all the various petroleum products that we rely on in everyday life. A diagram of this separation technique is shown in Fig. 9.1.

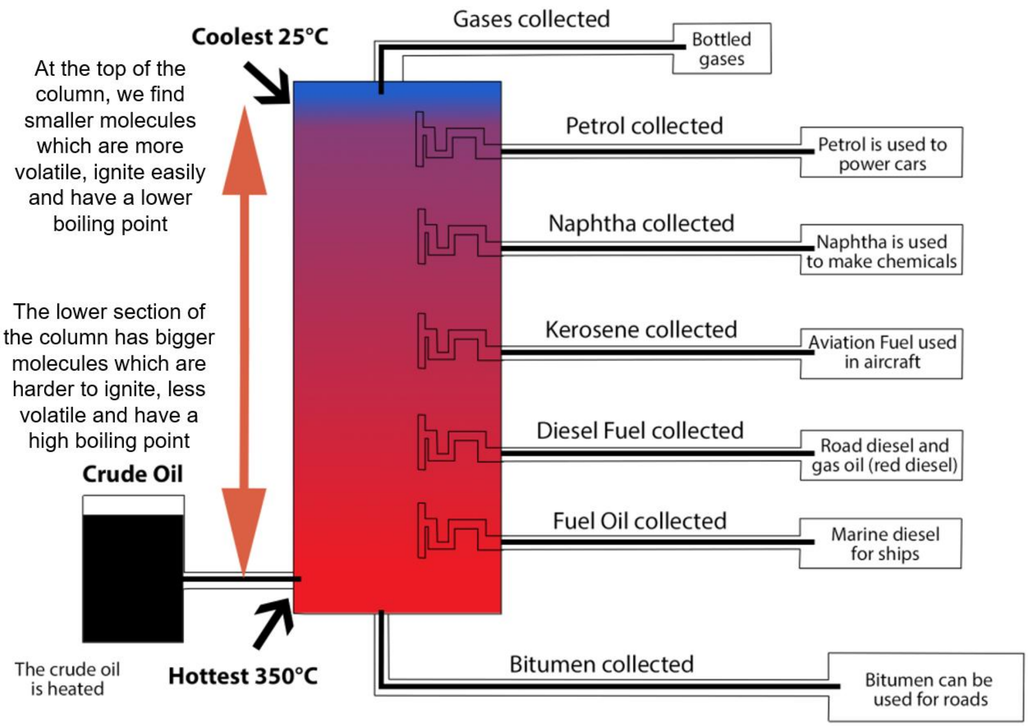


Fig. 9.1

Crude oil is heated and its components turn into vapour. They are subsequently cooled, condensed back into liquids, and collected as different fractions. Each fraction contains different hydrocarbons.

The top of the column gives rise to gases and liquids that have short carbon chains in their composition. While these products are often used as fuels, many have industrial and chemical uses too.

Hydrocarbons like butane, propane and other petroleum gases are formed right at the top of the tower, where it is coolest at a very mild 25°C. The temperature range that forms these gases is between 25°C and 50°C. These gases are the lightest products formed in this separation process and are flammable gases.

These gases, being the lightest products formed and flammable gases too, are then processed into Liquified Petroleum Gas (LPG), which is usually a mixture of propane and butane. LPG is used for heating applications and for hot air balloons in the case of propane.

The petroleum gases have four or five hydrocarbons in their chain. For these distillates, hydrocarbon chains are made up of three carbon atoms in the case of propane (C_3H_8), and four carbon atoms in the case of butane (C_4H_{10}).

Everyday use of the components of crude oil

Internal combustion engine fuels such as petrol or diesel fuels our cars' engines, gas oil powers machinery and furnaces, kerosene fuels aircraft, and domestic and commercial heating oil keeps our homes and workplaces warm.

In such combustion reactions, hydrocarbons react with oxygen in the air to produce carbon dioxide and water.

(a) **(i)** Name the separation technique used to separate crude oil.

Fractional distillation. (*Reject: spelling errors)*

R: Distillation [1]

(ii) Explain how the physical property of the components of crude oil allows them to be separated by this separation technique.

The components have a **difference** in their **boiling points**. [1]

(iii) Suggest and explain if oil industries can use separating funnels to separate the components of crude oil.

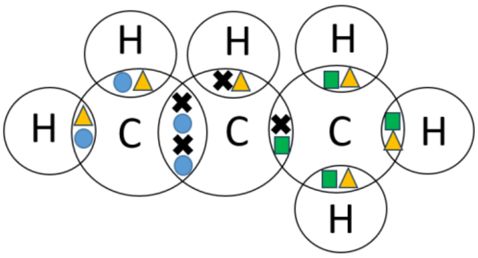
No. The components are **miscible**/ **can mix**. [1]

(b) Propene, C_3H_6, is a hydrocarbon that is a possible by-product of this separation technique.

(i) Suggest what is meant by the term *hydrocarbon*.

A substance/compound that contains **only hydrogen and carbon**. [1]

(ii) Draw a 'dot-and-cross' diagram to show the bonding in propene. Show the outer shell electrons only.



[1] one C=C double bond and one C-C single bond seen
[1] correct arrangement of electrons and atoms

Accept if students used the same symbol for alternating C atoms (e.g. dot for carbon 1 and 3)
Accept if students used different symbols from answer key, as long as different symbols are used to represent electrons

[2]

(iii) Substances that produce ions when dissolved in water are called electrolytes. Electrolytes are used as mediums to conduct electricity in electrolysis reactions.

Suggest and explain whether propene can be used as an electrolyte.

No.

Propene is a simple covalent molecule/compound and **does not have any mobile electrons/ mobile ions** to act as mobile charge carriers to conduct electricity.

[1]

(iv) Write a balanced chemical equation for the combustion reaction of propene.

$2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$

(Don't need state symbols) [1]

(v) Other than using chromatography, explain how the purity of propene obtained from the separation can be determined.

Check the melting/boiling point of propene. If it has a **fixed melting/boiling point**, it is **pure**.

OR

Check the melting/boiling point of propene. If it has a **range of melting/boiling point**, it is **impure**.

[1]

(c) Chromatography was performed on a sample of crude oil. The results are shown in Fig. 9.2.

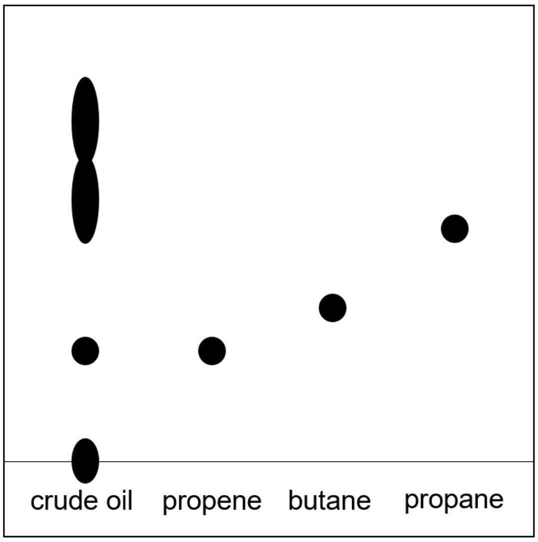


Fig 9.2

State three conclusions that can be drawn by using evidence from Fig 9.2.

Any three of the following:

- Some components of crude oil are **not soluble in the solvent** chosen as there is **still a spot left on the starting line**. [1]
- Some components of crude oil have **similar Rf values/ do not separate well** in the solvent chosen. This can be seen from the **overlapping spots**. [1]
- Propene, butane and propane are **pure** substances/compounds as they **produce only one spot**. [1]
- Crude oil contains **at least** **4 components** as it produced **at least 4 spots**. [1]
- Crude oil is **impure** as it produced **at least 4 spots**. [1]
- Propane is **more soluble than propene and butane** as its **spot travelled a further distance/ is at a higher height** than the **spots of propene and butane**. [1]
- Crude oil **contains propene** as the **spot in crude oil is at the same height as the propene's spot**. [1]
- Crude oil **does not contain butane** as there is **no spot in crude oil that is at the same height as the butane's spot**. [1]

Note: Students need to state the conclusion AND give supporting evidence from Fig 9.2 to score each 1m.

[3]

[Total: 12]

SECTION B [10 marks]

Answer **one** question from this section.

B11 25.0 cm^3 of 0.40 mol/dm^3 sulfuric acid was reacted with exactly 35 cm^3 of sodium hydroxide.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(a) Calculate the concentration of sodium hydroxide used.

no. of moles of sulfuric acid = vol × conc
= 0.025 × 0.40
= 0.01 mol [1]

no. of moles of sulfuric acid : sodium hydroxide = 1 : 2
= 0.01 mol : 0.02 mol

concentration of sodium hydroxide = no. of moles ÷ vol
= 0.02 ÷ 0.035
= 0.57143 (5sf)
= 0.571 mol/dm^3 (3sf) [1]

[2]

(b) Write the ionic equation, with state symbols, for this reaction.

$H^+ (aq) + OH^- (aq) \rightarrow H_2O\ (l)$ [1]

(c) Sodium sulfate solution is obtained at the end of the reaction.

(i) Describe what would be observed if a few drops of universal indicator were added to the sodium sulfate solution.

The **colourless** sodium sulfate solution **turns green**. [1]

(ii) Describe the concentration of H^+ and OH^- ions present in the sodium sulfate solution at the end of the reaction.

The concentration of H^+ and OH^- ions are **equal**. [1]

(d) Describe the steps to prepare pure and dry sodium sulfate crystals from sulfuric acid and sodium hydroxide.

1. Using a pipette, transfer 25.0 cm^3 of dilute sodium hydroxide (aq) into a clean conical flask.
2. Add 1 – 2 drops of methyl orange indicator to aqueous sodium hydroxide. The solution turns yellow.
3. Fill a burette with dilute sulfuric acid. [1] Note the initial burette reading.
4. Release the acid into the conical flask slowly, swirling the conical flask at the same time. Continue until 1 drop of the acid turns the indicator from yellow to orange. [1] This is the end-point.
5. Record the final burette reading and measure the volume of dilute sulfuric acid required ($V_2 – V_1$) cm^3 for complete neutralisation. [1] (Repeat)
6. **Pipette 25.0 cm^3 of dilute sodium hydroxide** into a conical flask without adding any indicator.
7. Add ($V_2 – V_1$) cm^3 of dilute sulfuric acid from the burette. [1] (From step 5)
8. **Heat** the solution until **saturated** and allow it to **cool** and **crystallise**.
9. **Filter** to obtain the crystals. **Wash** with **a little cold distilled water** to remove the impurities.
10. **Dry** the crystals with pieces of filter paper. [1]

[5]

[Total: 10]

B12 30.0 cm^3 of 0.80 mol/dm^3 nitric acid was reacted with 10 g of magnesium.

(a) Calculate the mass of magnesium nitrate produced.

$2HNO_3 + Mg \rightarrow Mg(NO_3)_2 + H_2$

no. of moles of nitric acid = vol × conc
= 0.030 × 0.80
= 0.024 mol

no. of moles of magnesium = mass ÷ A_r
= 10 ÷ 24
= 0.41667 mol (5sf)

[1] for determining no. of moles of nitric acid OR magnesium correctly

Using no. of moles of nitric acid, 0.024 mol of nitric acid reacts with 0.012 mol of magnesium. Since there are 0.41667 mol of magnesium, magnesium is in excess and nitric acid is the limiting reagent. [1] *for determining limiting reagent*

OR

Using no. of moles of magnesium, 0.41667 mol of magnesium reacts with 0.83334 mol of nitric acid. Since there is only 0.024 mol of nitric acid, nitric acid is the limiting reagent.
[1] *for determining limiting reagent*

no. of moles of nitric acid : magnesium nitrate = 2 : 1
= 0.024 mol : 0.012 mol

mass of magnesium nitrate produced = no. of moles × M_r
= 0.012 × [24 + 2(14 + 3 × 16)]
= 0.012 × 148
= 1.776
= 1.78 g (3sf) [1]

[3]

(b) A gas was produced in this reaction. Describe the test and observation to confirm the identity of the gas.

Insert a lighted splint into the test gas/ at the mouth of the test tube.
The lighted splint **extinguishes with a pop sound**. [1]

[1]

(c) Suggest a change in observation if nitric acid was replaced with ethanoic acid, CH_3COOH, for this reaction. Explain why.

[1] Any of the following:

- The reaction takes a **longer time** to complete.
- Effervescence/Bubbles is/are produced at a **slower rate**.

[R] *Less* effervescence/bubbles produced. (The comparison should be speed, not quantity)

Ethanoic acid is a **weak acid** that only **partially ionises in water** to **produce a low concentration of H+ ions** as **compared** to the **same volume of nitric acid**. [1]
OR
Ethanoic acid is a **weak acid** that only **partially ionises in an aqueous solution/water** while nitric acid is a **strong acid** that **completely ionises in an aqueous solution/water.** [1]

[2]

(d) Describe the steps to prepare pure and dry magnesium nitrate crystals from nitric acid and magnesium.

1. With constant stirring, add **excess magnesium** strips/powder into a beaker of dilute nitric acid **until no more effervescence is observed**. [1]
2. **Filter** to **remove** the **excess** unreacted **magnesium** as the residue. Collect the filtrate, magnesium nitrate solution. [1]
3. The filtrate is heated to evaporate off excess water. The solution is **heated until it is saturated**.
4. The saturated solution is allowed to **cool** and **crystallise** to form magnesium nitrate crystals. [1]
5. The magnesium nitrate crystals are **filtered** and recovered as residue in the filter paper. The crystals are **washed** with **a little cold distilled water** to remove impurities. **Dry** the crystals by pressing them between dry sheets of **filter paper** and left to dry. [1]

[4]

[Total: 10]

END OF PAPER