Yr11 ATAR CHEMISTRY

SEMESTER TWO EXAM 2017

SCOTCH
COLLEGE

Name: Solutions.

Reading time before commencing work: **10 minutes**
Working time for paper: **3 hours**

To be provided by the supervisor
Question/answer booklet, data book

To be provided by the student
Standard items: Pens, pencils, eraser, correction fluid, ruler, highlighter
Special items: Calculator. **Programmable calculators are *not* permitted.**

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Section One: Multiple-choice **28% (50 marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

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1. Which one of the following is the best conductor of electricity at 25 ^{0}C?

   A. Water. Covalent molecular (very weak electrolyte)
   B. An aqueous solution of potassium chloride. ionic - free moving ions
   C. Solid silicon dioxide. Covalent network
   D. Solid sodium chloride. ionic - ions trapped in lattice

2. Two isotopes of Strontium are Sr^{86} and Sr^{87}. Which statement is **FALSE**?

   A. They both have the same number of protons. ✓ since they are the same element
   B. They both have the same number of electrons. ✓ " " "
   C. The relative atomic mass of Strontium is between the two isotopic masses. ✓
   D. The atomic mass minus the atomic number will be the same for both. ✗

   Atomic mass
   since RAM is a weighted average mass of atoms
   since the atomic no is the same (same element)

3. The -2 ion of element X has an electron configuration of 2,8,8. Which of the following statements is true based on information given?

   gained 2e⁻
   A. X is in period 3 and group 16
   B. X is in period 2 and group 2
   C. X is in period 3 and group 2
   D. X is in period 2 and group 16

   So it was 2,8,6
   6 valence e⁻s ∴ group 16.
   3 shells ∴ 3rd period

4. Consider the reaction below:
   Potassium Hydrogencarbonate decomposes to Potassium Carbonate, Water and Carbon Dioxide
   The correct coefficients of the balanced equation are;

   A. 1,1,1,1
   B. 1,2,1,2
   C. 2,1,2,1
   D. 2,1,1,1

   $2KHCO_3 \longrightarrow K_2CO_3 + H_2O + CO_2$

layers of hexagons 3 bonds each soft, slippery — spare e⁻ conductor

5. Which one of the following statements about graphite and diamond is **true**?

A. They have the same crystal lattice structure. ×
B. They have the same degree of hardness. ×
C. They have the same electrical conductivity. ×
D. They can undergo the same chemical reactions. ✓ same element

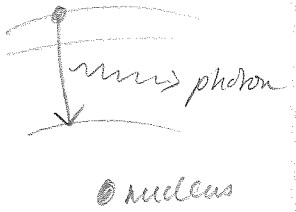
Tetrahedral 4 bonds each hard no spare e⁻s insulator

6. Which one of the following statements about the Group 1 metals is **false**?

A. Their atomic radii increase down the group. ✓ more shells (protons + shielding cancel)
B. Solutions made by dissolving their oxides would all have a pH > 7. ✓ basic oxides
C. Their ions have the electronic configuration of a noble gas. ✓ lose e⁻ to get full shell
D. Their melting points increase down the group. × ions in metallic lattice get bigger, bonds get weaker

7. The light emitted from a fireworks display is produced when electrons in an excited state;

A. absorb energy as they move to lower energy states
B. release energy as they move to higher energy states
C. release energy as they move to lower energy states
D. absorb energy as they move to higher energy states



8. Which of the following fertilisers contains the largest percentage by mass of nitrogen?

A. ammonium chloride, $NH_4C\ell$, M_r = 53.49 — 14.01/53.49
B. ammonium sulfate, $(NH_4)_2SO_4$, M_r = 132.13 — 28.02/132.13
C. potassium nitrate, KNO_3, M_r = 101.10 — 14.01/101.10
D. sodium nitrate, $NaNO_3$, M_r = 84.99 — 14.01/84.99

9. In a solution containing a mixture of sodium nitrate and sodium sulfate, the concentrations of sodium ions and nitrate ions are 0.500 mol L^{-1} and 0.200 mol L^{-1} respectively. What is the concentration of **sulfate** ions?

A. 0.100 mol L^{-1}
B. 0.150 mol L^{-1}
C. 0.200 mol L^{-1}
D. 0.300 mol L^{-1}

only from $NaNO_3$ ∴ 0.200 mol
from $NaNO_3$ AND Na_2SO_4 (0.500 − 0.200)
Na^+ 0.200 from $NaNO_3$ ∴ 0.300 from Na_2SO_4
∴ 0.150 mol of SO_4^{2-} since $2Na^+ : 1SO_4^{2-}$

10. When 1 mol L^{-1} aqueous solutions of the substances below are mixed, in which cases will a white precipitate be formed?

I. $AgNO_3$ and $NaC\ell$ ✓ $AgCl(s)$
II. $CuC\ell_2$ and K_2CO_3 × $CuCO_3(s)$ (green)
III. $Ba(NO_3)_2$ and K_2SO_4 ✓ $BaSO_4(s)$
IV. $Pb(NO_3)_2$ and Na_3PO_4 ✓ $Pb_3(PO_4)_2(s)$

A. I, II, III and IV
B. II and III only
C. I, III and IV only
D. II only

11. Flask X contains 1 mol of gas at 250 K.
Flask Y contains 2 mol of gas.
The volumes of flasks X and Y are the same.

If all other conditions were the same, P in Y should be 2x P in X

The pressure in flask X is the same as the pressure in flask Y. This could be explained if the gas in flask Y:

A. had half the relative molecular mass of the gas in flask X. × Makes no difference to no of particles
B. was at a temperature of 125 K. ✓ Since $P \propto T$
C. was composed of diatomic molecules. × Irrelevant
D. had half as many molecules as the gas in flask X. × we are told it has 2x as many!

12. In which of the following would particles have the highest average velocity at standard temperature and pressure?

A. Carbon monoxide $12+16=28$
B. Ethane $2\times12+6=30$
C. Hydrogen fluoride $1+19=20$
D. Nitrogen $2\times14=28$

all at same T
∴ all have same K.E (average)
$KE = \frac{1}{2}mv^2$
∴ LIGHTEST particles (Smallest m) will move FASTEST (largest v)

See next page

13. A liquid placed in a thermally insulated open beaker is evaporated by a stream of air from a fan. As the liquid evaporates, which one of the following occurs to the molecules remaining in the liquid?

A. Their average kinetic energy increases.
B. The rate of collision between the remaining molecules increases.
C. Their average velocity decreases.
D. Their molecular radius decreases.

14. At 20°C the vapour pressure of ether, $C_4H_{10}O$, is 58.9 kPa while that of chloroform, $CH_3C\ell$, is 19.3 kPa. From this information we can deduce that:

A. ether has a lower boiling point at atmospheric pressure than chloroform.
B. ether has stronger intermolecular forces than chloroform.
C. chloroform will boil at a lower temperature than ether.
D. chloroform has stronger covalent bonds between its atoms than ether.

15. Which of the following processes is endothermic?

A. $CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$
B. $H_2O_{(s)} \rightarrow H_2O_{(l)}$
C. $H_2O_{(g)} \rightarrow H_2O_{(l)}$
D. $2\,C\ell \rightarrow C\ell_2$

16. Measured at constant temperature, the rates of chemical reactions decrease as reactions proceed because:

A. the reactant concentrations decrease with time.
B. a catalyst is needed to maintain a constant rate of reaction.
C. the fraction of reactant molecules with energies in excess of the activation energy decreases as the reaction proceeds.
D. absorption of heat by the reaction diminishes the reaction rate.

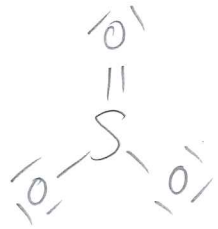
17. The emission spectra for an Element can be used to do what?

A. Determine the mass of the sample
B. Determine the identity of the element
C. Determine the number of moles of the element
D. Determine the number of electrons

See next page

18. The shape of sulfur trioxide could best be described as:

A. tetrahedral
B. bent
C. pyramidal
D. triangular planar



S - 6
O_3 - 6 x 3
24 e⁻s
12 pairs.

19. The conjugate base of the species HSO_3^- is:

A. HSO_3^{2-}
B. SO_3^{2-}
C. H_2SO_3
D. $H_2SO_3^-$

"The base that could gain H^+ and become..."

20. What amount of gaseous HCℓ must be dissolved in 1.00 litre of aqueous hydrochloric acid solution to change its pH from 3 to 2? *(Assume no volume change occurs)*

A. 0.0090 mole
B. 0.090 mole
C. 0.01 mole
D. 1.0 mole

$0.001\ mol\ L^{-1} \longrightarrow 0.01\ mol\ L^{-1}$

So we need to add 0.010
− 0.001
0.009 mol

21. Which of the following statements concerning the Brønsted-Lowry theory of acids and bases is FALSE?

A. When a proton is donated by one species to another in aqueous solution, the reaction is classified as acid-base ✓
B. The ability to accept protons from other species in aqueous solution is a property of bases. ✓
C. A base is produced when a cation, anion or molecule donates a proton in aqueous solution. ✓
D. In aqueous solutions, bases are those cations, anions or molecules that donate protons to other species. ✗

transfer of H^+

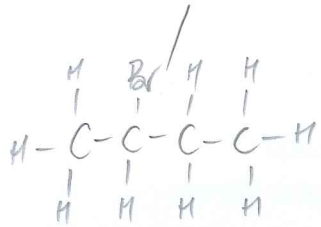
acids

The product could accept H^+ and reform the starting material.

See next page

22. When $Br_2(aq)$ is added to compound X in the presence of ultra violet light, the solution turns colourless, and the product formed is 2-bromobutane. The identity of X is therefore:

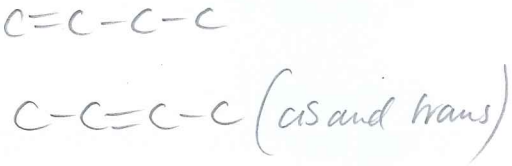
A. butane
B. but-1-ene
C. *cis*-but-2-ene
D. *trans*-2-butene

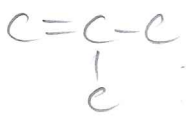


X cannot be an alkene, since ADDITION would have happened (2 x Br)

23. How many **alkene** isomers are there with molecular formula C_4H_8?

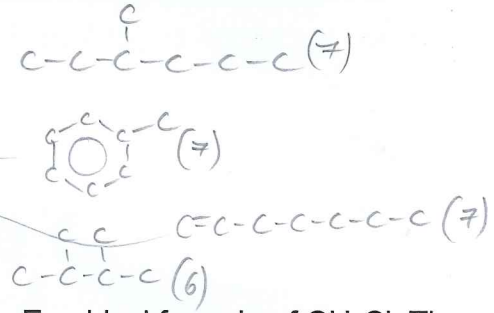
A. 2
B. 3
C. 4
D. 6





24. Which of the following substances contains a different number of carbon atoms from all the others?

A. 3-methylhexane
B. methylbenzene
C. hept - 1 - ene
D. dimethylbutane



25. An organic compound has an Empirical formula of CH_2Cl. The molar mass of the compound is 99 g mol^{-1}. The Molecular formula is;

A. CH_2Cl
B. C_2H_4Cl
C. $C_2H_4Cl_2$
D. CH_4Cl_2

$12.01 + 2.016 + 35.45 = 49.476$

$\sim \frac{1}{2} \times 99$

$\therefore$ MF = 2 x EF

Place a "X" in one of the responses for each question

See next page

	A	B	C	D
1		X		
2				X
3	X			
4				X
5				X
6				X
7			X	
8	X			
9		X		
10			X	
11		X		
12			X	
13			X	
14	X			
15		X		
16	X			
17		X		
18				X
19		X		
20	X			
21				X
22	X			
23			X	
24				X
25			X	

END OF SECTION ONE

See next page

Section Two: Short answer **39% (70 Marks)**

This section has **13** questions. Answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

Suggested working time: 70 minutes.

Question 26 **(4 marks)**

Give the name of each of the following substances.

a) $Co(NO_3)_2$ Cobalt(II) nitrate (do not allow cobalt nitrate)

b) $C_6H_5CH_3$ Methylbenzene / toluene

c) HNO_3 Nitric acid (allow hydrogen nitrate)

d) P_2O_5 Diphosphorus Pentoxide.

Question 27 **(4 marks)**

Name the **strongest** intermolecular force involved in each of the following substances.

a) $CH_3CH_2CH_3$ Disp.

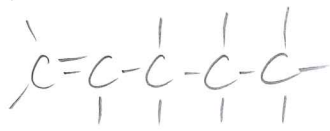
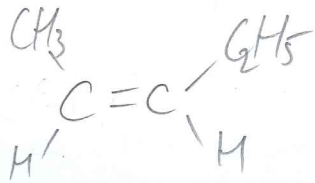
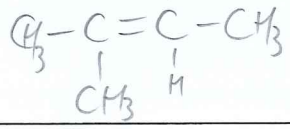
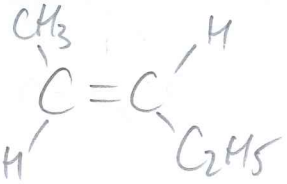
b) H_2O H-bond

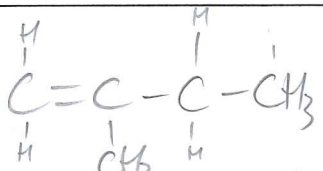
c) CH_3CH_2OH H-bond

d) CH_3Cl Dip-Dip

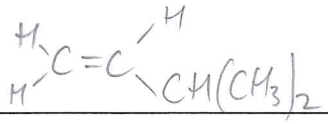
Question 28 **(8 marks)**

Draw the full structural formulae and give the IUPAC names of four **non-cyclic** isomers of C_5H_{10}.

Structural Formula	IUPAC Name
	1-pentene / pent-1-ene
	(cis) 2-pentene / pent-2-ene
	methyl-2-butene
	(trans) 2-pentene / pent-2-ene



2-methyl-1-butene



3-methyl-1-butene.

Question 29 **(3 marks)**

Complete the following table.

Species	No. of Protons	No. of Neutrons	Electron Configuration
^{14}C	6	8 ✓	2,4 ✓
$^{81}Br^-$	35 ✓	46 ✓	2,8,8,17
$^{40}Ca^{2+}$ ✓ ✓	20	20	2,8,8

½ each.

See next page

Question 30 **(4 marks)**

One of the consequences of increasing carbon dioxide levels in the atmosphere is that more carbon dioxide is dissolved in the oceans, leading to increased acidification due to the presence of carbonic acid (H_2CO_3), which partially ionises to form the hydrogen carbonate ion.

a) Write an equation to show how carbonic acid is able to act as an acid when dissolved in water.

(2 marks)

$H_2CO_3 + H_2O \rightleftharpoons HCO_3^- + H_3O^+$ ✓✓

(or) $H_2CO_3 + 2H_2O \rightleftharpoons CO_3^{2-} + 2H_3O^+$ ✓✓

b) Identify the conjugate base of the hydrogen carbonate ion.

(1 mark)

CO_3^{2-}

Sea water normally has a pH of around 8. With increasing carbon dioxide levels it has been measured in some oceans to have changed to 6.

c) By what factor has the concentration of H^+ ions in increased/ decreased?

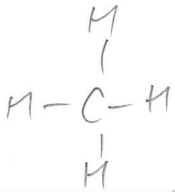
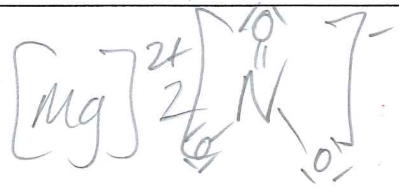
(1 mark)

Increased x 100

Question 31 **(5 marks)**

For each of the species listed in the table below, draw the Lewis structure (electron dot diagram), representing all valence shell electron pairs either as : or as — and shape.

(for example, water $H:\ddot{O}:H$ or $H-\ddot{O}-H$ o $H-\bar{\underline{O}}-H$)

Species	Lewis Structure	Shape
SO_2		Bent / Non-linear / V-shaped.
CH_4		Tetrahedral
$Mg(NO_3)_2$		n/a

Question 32 **(4 marks)**

Give the name or formula of substances that match the following descriptions.

a) A triprotic acid. Phosphoric Acid H_3PO_4

b) A substance that has delocalized electrons. C_6H_6 (benzene) C (graphite) Metal!

c) The third smallest saturated hydrocarbon. C_3H_8 (propane)

d) A weak electrolyte CH_3COOH ethanoic acid NH_3 ammonia H_2O water.

See next page

Question 33 **(12 marks)**

Give **balanced ionic** (where appropriate) equations for any reactions which occur in the following experiments. If no reaction occurs then write 'no reaction'.
In each case describe observations such as colour changes, precipitate formation (give the colour), or gas evolution (give the colour or describe as colourless) resulting from the chemical reaction. If no visible change occurs then you should state this.

Acid + Carbonate

a) A spatula full of calcium carbonate is placed in a test tube of dilute hydrochloric acid.

$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$ ✓

Equation $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + CO_2 + H_2O$ ✓

Observation White solid + c/less solution → c/less solution + Bubbles of c/less gas.

Substitution Alkane

b) Bromine water is added to hexane in the presence of sunlight.

Equation $Br_2 + C_6H_{14} \rightarrow C_6H_{13}Br + HBr$ ✓

Observation Orange solution turns c/less

precipitation

c) Barium chloride solution is added dropwise to a beaker of nickel (II) sulfate solution.

$BaCl_2 + NiSO_4 \rightarrow NiCl_2 + BaSO_4$ ✓

Equation $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ ✓

Observation c/less solution + Green solution → white ppt in green solution.

Acid + Base

d) A solution of potassium hydroxide is added to dilute nitric acid.

$KOH + HNO_3 \rightarrow KNO_3 + H_2O$ ✓

Equation $H^+ + OH^- \rightarrow H_2O$ ✓

Observation NVR

2 c/less solutions → c/less solution.

See next page

Question 34 **(5 marks)**

Bordeaux Mixture is the name of one of the earliest known chemical fungicides. It first found use in France in the late 19th century, being sprayed onto grapes at the side of the road to prevent pilfering, since it had an unpleasant taste. It was subsequently discovered that vines that had been sprayed with the mixture were not affected by mildew.

Bordeaux Mixture is made by dissolving quicklime (calcium oxide) in a solution of copper sulfate. Its concentration is usually given as a percentage by mass, so a typical 1% solution has 1kg of quicklime and 1kg of hydrated copper sulphate ($CuSO_4.5H_2O$) in every 100kg of solution.

a) Find the molar mass of hydrated copper sulfate. (1 mark)

$63.55 + 32.07 + 4\times16 + 10\times1.008 + 5\times16$

$= 249.7$

b) Find the percentage **copper** by mass in a 1% solution of Bordeaux Mixture. (2 marks)

$\%\ Cu \text{ in } CuSO_4.5H_2O = \frac{63.55}{249.7} = 25.4\%$

25.4% of $1\% = 0.254\%$

c) Calculate the concentration of **copper sulphate** in a 1% solution of Bordeaux Mixture in $molL^{-1}$. Assume density of solution is 1g/mL (2 marks)

1 L of solution weighs 1 kg - 1% of 1kg = 10g ✓

$\therefore$ concentration = 10g/L

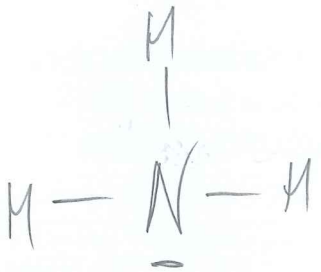
$n(CuSO_4) = n(CuSO_4.5H_2O) = 10g/249.7 = 0.04mol$ ✓

$\therefore$ $c = 0.04 mol L^{-1}$

See next page

Question 35 **(6 marks)**

Explain why ammonia (NH_3) is **polar** yet carbon dioxide (CO_2) is **non-polar**. Use terms like; non bonding electrons, shape, dipole. Lewis diagrams may help in your explanation.
(You do not have to use all these terms to get full marks)



- The non-bonding pair of electrons on N
- means that the shape is TRIGONAL PYRAMIDAL
- Bonds are polar (due to ELECTRONEGATIVITY DIFFERENCE between N + H)
- Lack of SYMMETRY means...
- Bond dipoles do not cancel

3 sensible points

- No non-bonding electrons on C atom
- means shape is LINEAR
- Bonds are polar (due to ELECTRONEGATIVITY DIFFERENCE between C and O)
- SYMMETRY of molecule means...
- Bond dipoles cancel

3 sensible points

Need points to be connected to score full marks.

See next page

Question 36 **(7 marks)**

Account for the following observations.

a) A 1 molL^{-1} solution of magnesium chloride has a lower vapour pressure at 35°C than a 1 molL^{-1} sodium chloride solution at the same temperature.

(3 marks)

$MgCl_2$ vs NaCl

↑more ions, and higher charge on Mg^{2+} than Na^+ ✓

↑

Stronger forces between ions and water molecules ✓

Harder for water to evaporate from $MgCl_2$ solution ✓

b) A 1 molL^{-1} solution of ethanoic acid is a poorer conductor of electricity than a 1molL^{-1} solution of nitric acid.

(2 marks)

✓ Ethanoic acid ionises partially, whereas ✓

Nitric acid ionises completely (no marks for strong/weak without explanation)

✓ Greater concentration of ions in HNO_3 (aq)

c) Solid carbon dioxide will sublime at -78°C, but solid silicon dioxide will melt at around 1650°C.

(2 marks)

CO_2 (covalent molecular) weak forces of attraction between molecules

SiO_2 (covalent network in which) strong covalent bonds must be broken in order to melt.

well

ll

See next page

Question 37 **(6 marks)**

Give a **chemical** test and observations that would enable you to distinguish between the following pairs of substances.

Substances	Test	Observations
Aromatic Benzene and Cyclohexene vs Alkene	Add $Br_{2(aq)}$ in dark (or $KMnO_{4(aq)}$)	Benzene: NVR Cyclohexene: Solution goes from orange (NOT red) → clear
Solutions of (1) potassium carbonate and potassium nitrate (2)	Add (dilute) acid (or some form of precipitation reaction)	Potassium carbonate: Bubbles of clear gas Potassium nitrate: NVR.

In this case, if for example $BaCl_2$ is added to both, full marks only to be awarded if students are clear about (s)/(aq), and give observations that are appropriate. eg...

Add $BaCl_{2(s)}$
(1) NVR
(2) White solid dissolves

(or)

Add $BaCl_{2(aq)}$
(1) White ppt forms
(2) NVR

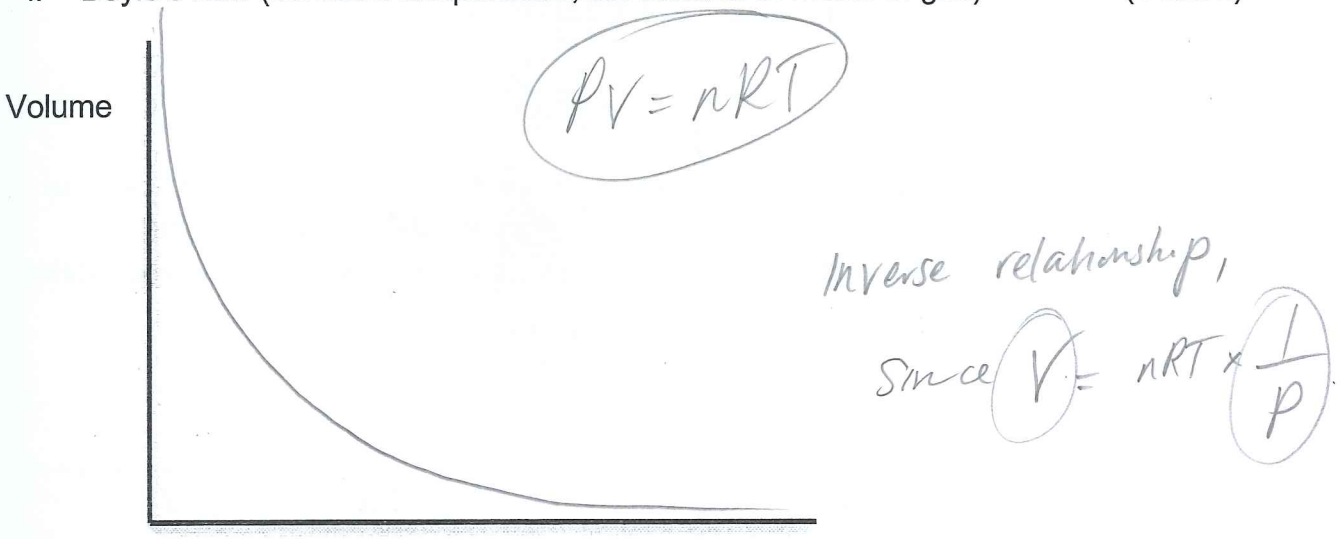
See next page

Question 38 **(2 marks)**

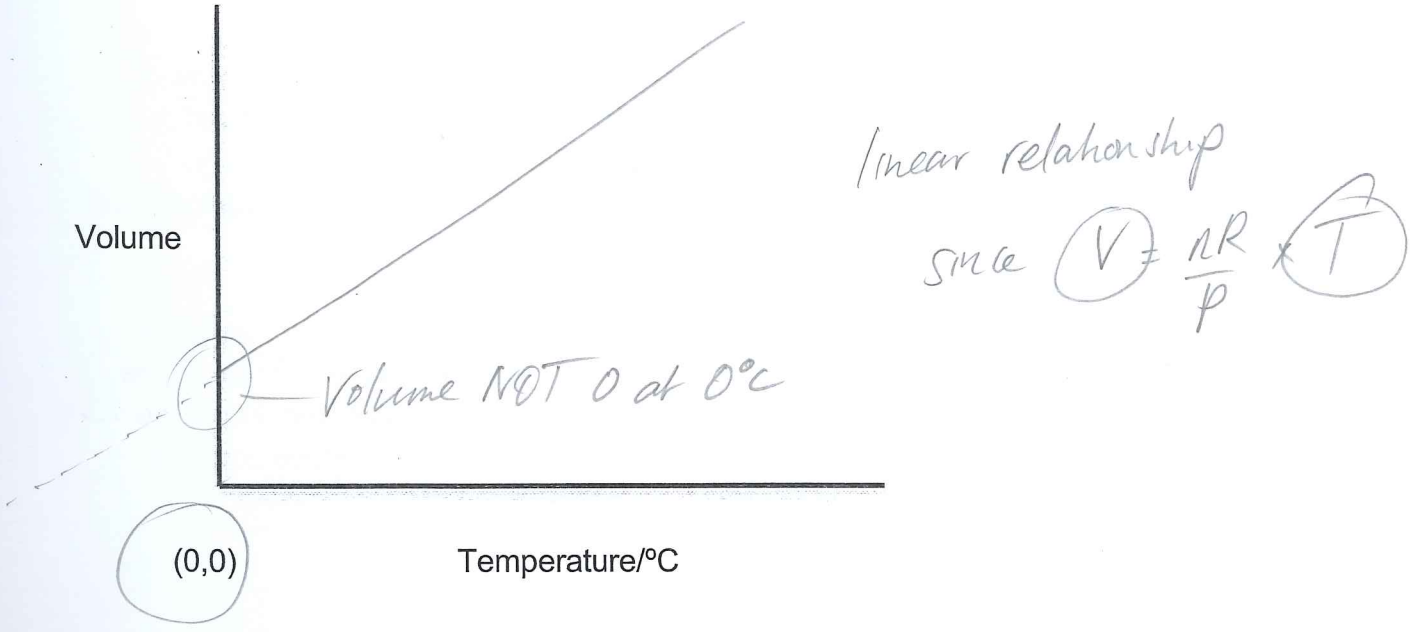
During the 17th and 18th centuries, experiments were being carried out to try and establish the relationships between volume, pressure, and temperature of gases. As a result of these experiments, a number of laws came into being: Boyle's Law (relates the pressure of a gas to its volume) Charles' law (relates the volume of a gas to its temperature) and Avogadro's hypothesis (relates the volume of a gas to the amount of gas present) (in moles). These laws were combined to give the Ideal Gas Law we use today.

a) On the axes below, sketch graphs to show the relationships governed by these laws.

i. Boyle's Law (constant temperature, set number of moles of gas) (1 mark)



ii. Charles' Law (constant pressure, set number of moles of gas) (1 mark)



END OF SECTION TWO

See next page

Section Three: Extended answer **33% (60 marks)**

This section contains **FOUR (4)** questions. Answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression.

Final answers to calculations should be expressed to three (3) significant figures.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

Question 39 **(19 marks)**

The Pilbara region in Western Australia is one of the leading iron ore producing areas in the world. The ore that is mined contains a number of minerals, including hematite, magnetite, and titano-magnetite.

Iron has been extracted from its ores since the 5th century BC, but the development of coke blast furnaces (as opposed to charcoal) in 1709 enabled much more efficient extraction. This method of extraction changed relatively little up to the 21st century. Kwinana is now the site of a new HIsmelt iron production plant, which, it is envisaged, will one day produce up to 800,000 tonnes of iron each year.

The technology promises to offer a lower cost and cleaner alternative to the traditional blast furnace process, but the chemical reactions taking place are largely similar. In the smelter, fine iron ore and coal are injected directly into a bath of molten iron. Here, the carbon dissolves in the molten metal, and reacts with iron oxides to produce iron and carbon monoxide.

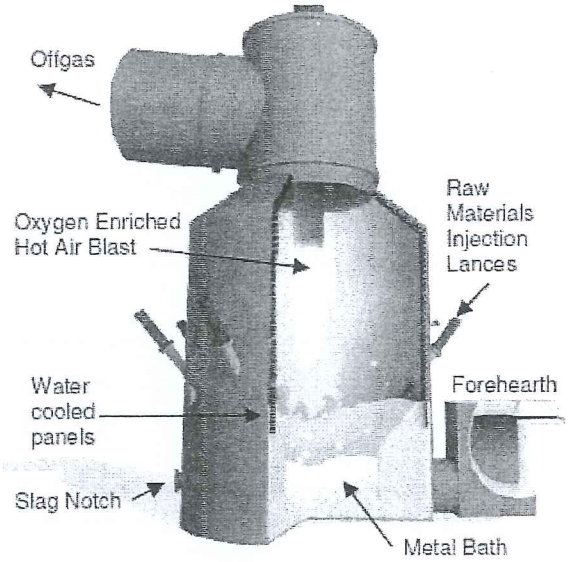
See next page

a) Balance the equation for the reaction taking place between the carbon and iron oxide.

(1 mark)

$$\_\_Fe_2O_3 + \underline{3}\,C \rightarrow \underline{2}\,Fe + \underline{3}\,CO$$

The diagram below shows the design of a HIsmelt furnace.



b) Explain, using collision theory, why it is important that the iron ore and coke are finely divided when they enter the molten iron bath at the bottom of the furnace.

(2 marks)

Increases surface area, so more particles exposed to collisions.

More frequent collisions → faster rate

1 mark for "Higher SA → higher rate"

c) The rapid expulsion of carbon monoxide causes a fountain of molten metal and slag droplets to rise up inside the furnace. A hot air blast is used to combust the carbon monoxide released by the reaction. The air in the blast is enriched with up to 35% oxygen to aid this combustion.

Explain using collision theory what effect the enrichment of the oxygen content has on the rate of reaction between the gases.

(2 marks)

Increases conc(O_2) ∴ more particles present per unit volume

More frequent collisions ∴ higher rate

(not just "more collisions" or "more particles")

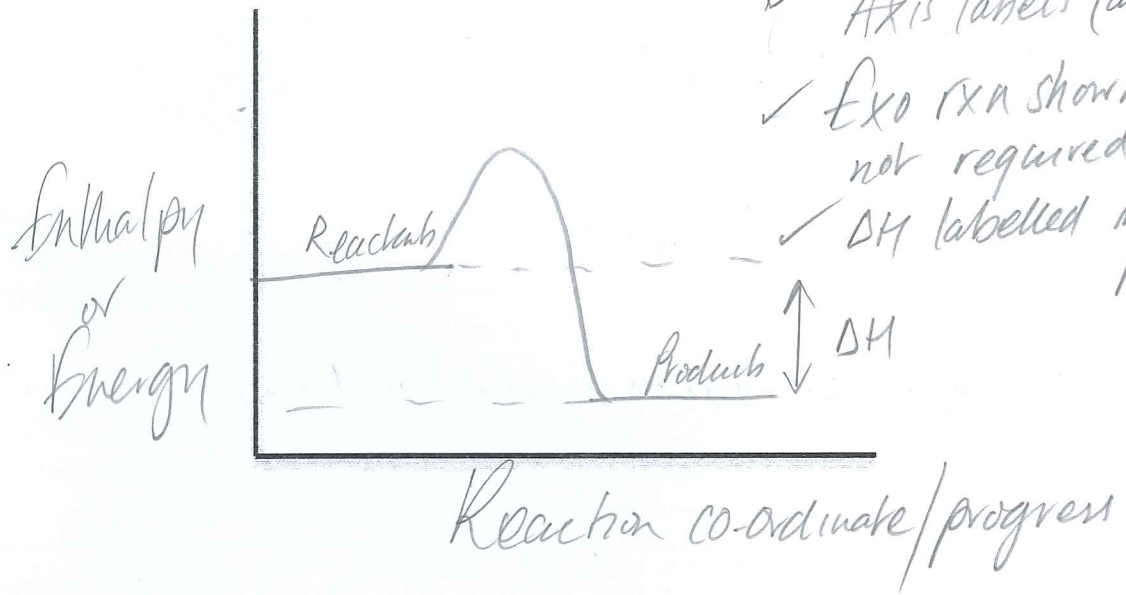
1 mark for "higher conc → higher rate"

d) The equation for the reaction between carbon monoxide and oxygen is shown below:

$$2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)} \quad \Delta H = -566 kJmol^{-1}$$ Exo

On the axes below, draw an energy level diagram for the reaction. Ensure that you label the axes, reactants and products, and the enthalpy change clearly.

(3 marks)



✓ Axis labels (and levels)
✓ Exo rxn shown (curve not required)
✓ ΔH labelled in correct place.

One of the advantages of the HIsmelt process compared to traditional blast furnace methods of extraction is the flexibility it offers with regard to ores used, meaning less processing is required.

e) If 500kg of direct shipping iron ore, containing 60% Fe_2O_3 are fed into the furnace, together with 500kg of coke, find the limiting reagent (assume the coke is 100% carbon).

(4 marks)

$n(Fe_2O_3) = m/M = \frac{60\% \times 500{,}000g}{55.85 \times 2 + 3 \times 16} = \frac{300{,}000}{159.7}$

$= 1890 mol$ ✓

$n(C) = \frac{500{,}000}{12.01} = 41600 mol$ ✓

Equation from part a) tells us 1 mol of Fe_2O_3 needs 3 mol C

∴ 1890 mol Fe_2O_3 require $(1890 \times 3) = 5670$ mol C

award follow-through

✓ But we have 41600 mol C, which is more than enough so Fe_2O_3 is LR

* Not just a recipe with no reasoning.

(Need clear reasoning AND correct working for full marks)

See next page

Max 2 if based on XS reagent (allow follow-through)

f) What mass of molten iron would be formed in the reaction?

(3 marks)

Equation from a) tells us $n(Fe) = 2n(Fe_2O_3)$ ✓

$\therefore n(Fe) = 2 \times 1890 = 3780$ mol ✓

$m(Fe) = n \times 55.85 = 211$ kg ✓ (3sf)

g) What volume of carbon dioxide would form (the molar volume of a gas at 1200°C and 100kPa is 122.5L)?

(2 marks)

$n(CO_2) = n(CO)$ (equation a)

$n(CO) = 3 \times n(Fe_2O_3) = 3 \times 1890 = 5670$ mol ✓

$V = n \times 122.5\text{L} = 695\text{ L}$ (3sf)

(or) $V = \frac{nRT}{P} = \frac{5670 \times 8.314 \times 1473.15}{100} = 694\text{ kL}$ (3sf) ✓

694,000 L

h) What volume of air would need to be blasted into the furnace to provide the oxygen for the combustion of this carbon monoxide (you may assume the air is at the same temperature and pressure as the gases in the furnace)?

(2 marks)

O_2 is ~20% by volume in air

$n(O_2) = \frac{1}{2} n(CO) = \frac{1}{2} \times 5670 = 2835$ mol ✓

$V = n \times 122.5 \times \frac{100}{20} = 1740\text{ kL}$ $(1.74 \times 10^6\text{ L})$

(or) $V = \frac{nRT}{P} \times \frac{100\%}{20\%} = \frac{2835 \times 8.314 \times 1473.15}{100} \times 5 = 1740\text{ kL}$ ✓

if 35% used, then $V = n \times 122.5 \times \frac{100}{35} = 992\text{ kL}$ (3sf)

See next page

Question 40 **(19 marks)**

The Argyle diamond mine in the Kimberley region of Western Australia has been in operation since 1983, producing more than 750 million carats of rough diamonds. Current reports suggest a mine life up to 2018. Argyle diamonds are renowned for their unusual colours. Whereas most diamonds mined in well known diamond regions, such as South Africa, find application in cutting tools and drilling, the rare pink diamonds from the Argyle mine are used exclusively for fine jewellery.

a) Using your knowledge of the bonding present in diamond, explain why it is ideally suited to cutting and drilling applications.

(3 marks)

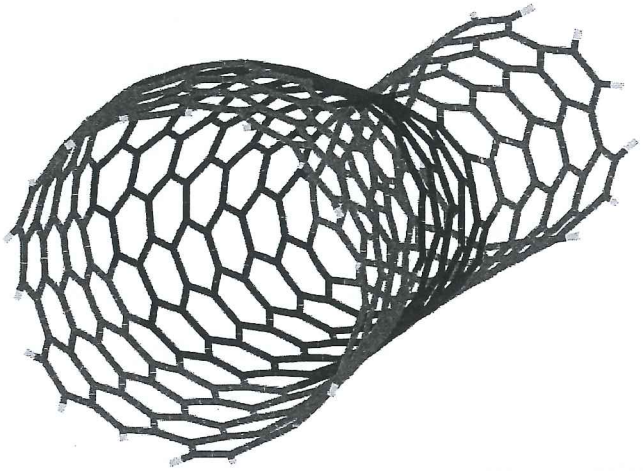
✓ Each Carbon attached to 4 others (in covalent network)

✓ Using strong covalent bonds

✓ Strength of lattice makes diamond v. hard. ✓

See next page

Graphene is an allotrope of carbon similar to graphite. The diagram below shows a sheet of graphene wrapped into a structure known as a *nanotube*.



b) Define the term *allotrope* (1 mark)

Same element, different structural forms

c) Using your knowledge of the bonding present in graphite, and the diagram above, describe the ways in which graphene's structure is similar to that of graphite. (2 marks)

✓ Both have 3 bonds to each C atom

✓ Both form "layers" of hexagons

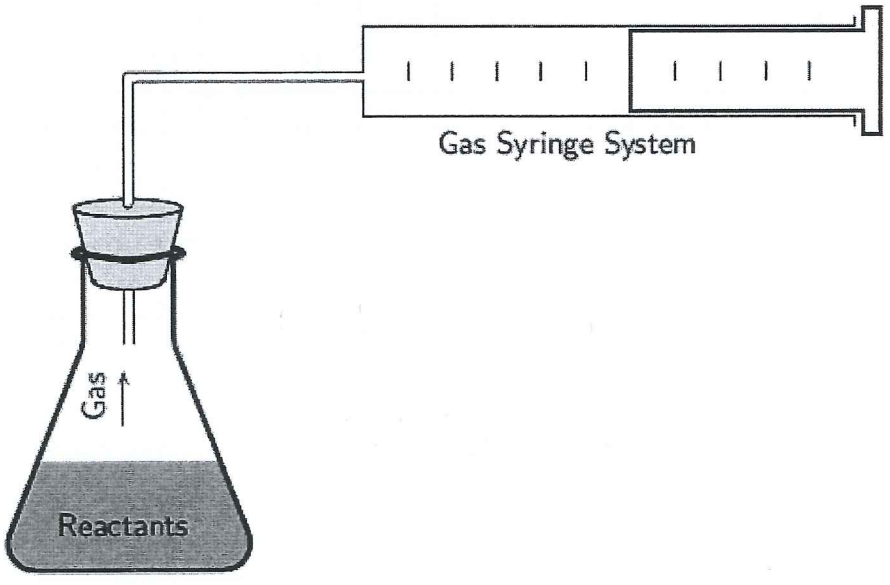
✓ Both have spare electrons

Aluminium is one of the most common elements in the earth's crust, but is one of the most expensive metals to produce, largely because of the cost of replacing the huge carbon anodes, and the cost of supplying electricity to the cells.

d) For the following uses of aluminium, give a property of the metal which makes it particularly suitable for that use. (3 marks)

Use	Property
Cooking foil	Good conductor / unreactive
Overhead cables	Good conductor / unreactive / low density
Aircraft manufacture	Low density / unreactive (NOT high strength)

Students wishing to investigate the possibility of cooking foil reacting with food acids carried out an experiment where a piece of aluminium foil was placed in hydrochloric acid in a conical flask, and the flask connected to a gas syringe. A diagram of the equipment is shown below.



e) Write a balanced ionic equation for the reaction taking place. (2 marks)

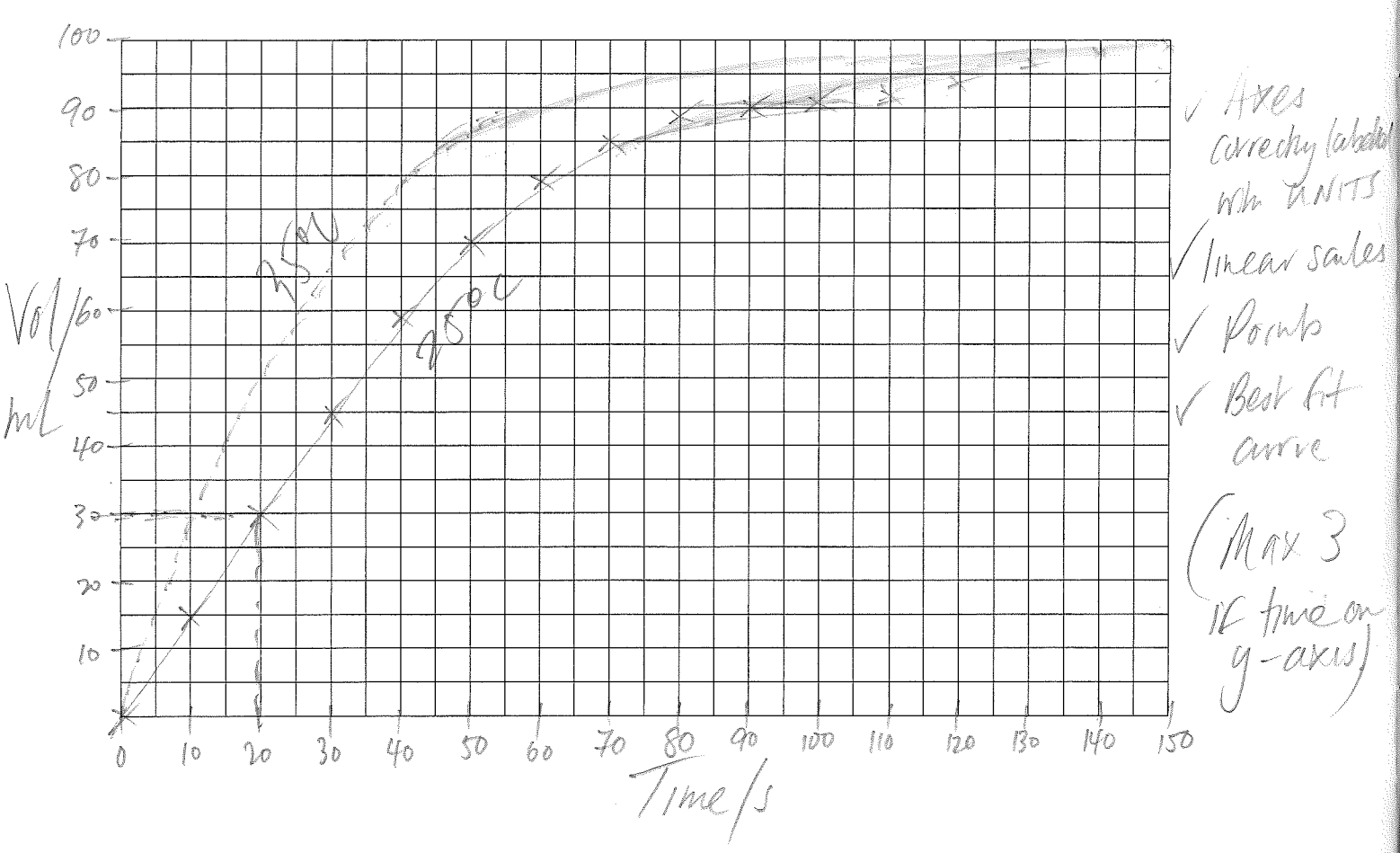
$2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$ ✓

$2Al + 6H^+ \rightarrow 2Al^{3+} + 3H_2$ ✓✓

It was decided that the volume of gas would be measured every minute until the reaction was complete. The reaction was carried out at 25°C. The results of the experiment are shown in the table below.

Time/s	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Volume/mL	0	15	30	45	58	70	78	85	88	90	92	94	96	98	99	100

Graph the data on the graph paper below (4 marks)



f) Use your graph to find the rate of reaction, in mL per second, after 20 seconds. (2 marks)

✓ 30 mL / 20 sec = 1.5 mL/s

g) On the same graph, sketch the results you would expect to see if the reaction had been carried out at a temperature of 35°C. Ensure you label this curve clearly. (2 marks)

✓ Steeper gradient / finishing sooner

✓ Finishing @ same volume.

See next page

Question 41 **(12 marks)**

An organic compound X, containing only carbon, hydrogen and oxygen, burns in oxygen to form carbon dioxide and water only. A 1.000 g sample of X produced 0.9310 g of H_2O and 2.28 g of CO_2.

a) Calculate the empirical formula of X. (6 marks)

$n(C) = n(CO_2) = 2.28/44.01 = 0.0518\ mol$ ✓

$n(H) = 2n(H_2O) = 2 \times 0.9310/18.016 = 0.103\ mol$

$m(C) = n \times M = 0.0518 \times 12.01 = 0.622\ g$ ✓

$m(H) = n \times M = 0.103 \times 1.008 = 0.104\ g$

$m(O) = 1.000 - 0.622 - 0.104 = 0.274\ g$ ✓

$n(O) = 0.274/16 = 0.0171\ mol$ ✓

	C	H	O
n	0.0518	0.103	0.0171
ratio	3	6	1

✓

EF = C_3H_6O ✓

b) Given that, when vapourised, 2.484 g of X occupied 972.7 mL at STP, determine the molar mass of X. (2 marks)

$PV = nRT \therefore n = \frac{PV}{RT} = \frac{100 \times 0.9727}{8.314 \times 273.15} = 0.0428\ mol$ ✓

$M = m/n = 2.484/ans = 58.0$ ✓ (3sf)

or use $M = \frac{mRT}{PV}$

See next page

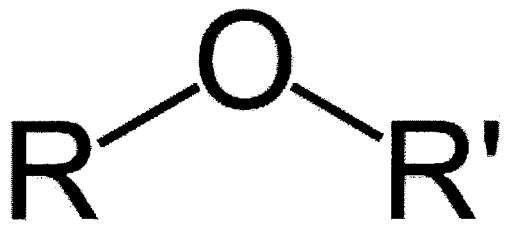
c) What is the molecular formula of X?

(2 marks)

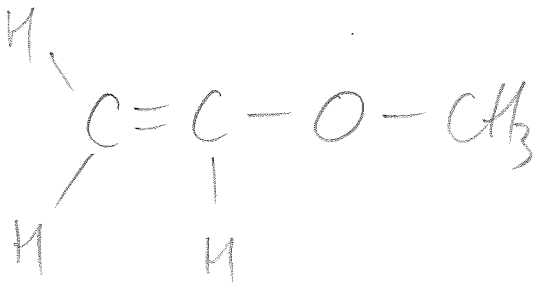
"M" or Ef = $3 \times 12.01 + 16 + 6 \times 1.008 = 58.078$

∴ MF = Ef = C_3H_6O

d) "X" has the following structure: were R and R' represent hydrocarbon chains



Draw a possible structure for "X" (2 marks)



Question 42 **(10 marks)**

Describe in detail the following methods of **separation** used in chemistry, Mass spectrometry and Chromatography.

a) How can we use mass spectrometry to separate two isotopes of Molybdenum, atomic mass 92 and 100? Use terms like; ionisation, acceleration, deflection and detection

In a mass spectrometer...

Sample is VAPORISED - turned into a gas using heat ✓

.. IONISED - turned into +ve ions using high energy e^-s ✓

.. ACCELERATED - through a narrow slit using an electric field ✓

.. DEFLECTED - using a magnetic field ✓ (different isotopes deflected by different amounts)

.. DETECTED - (having been separated in this way) by a computer (that counts them) ✓

Any FIVE (if incorrect order, MAX 4)

END OF SECTION THREE

See next page

b) How can we use chromatography to separate compounds in an ink? Use terms like; stationary phase, mobile phase, retardation factor and intermolecular forces.

(1) Place dot of ink close to bottom of filter paper (STATIONARY PHASE)

(2) Dip filter paper in a solvent (MOBILE PHASE)

(3) Solvent will travel up filter paper, dissolving the ink as it goes

(4) Different compounds in ink will form different strength IMFs with mobile/stationary phases

(5) Strength of these forces will influence distance travelled along stationary phase by compounds

(6) Retardation factor will be different for each compound

(7) $R_f = \frac{\text{distance travelled by compound}}{\text{distance travelled by solvent}}$

END OF SECTION THREE

Do not award separate marks for (5)/(6)

Any 5 points in sensible order

Max 4 if no order/organisation

See next page