PERTH MODERN SCHOOL
Exceptional schooling. Exceptional students.
INDEPENDENT PUBLIC SCHOOL

Year 11 Units 1 & 2 Examination, 2017

Question/Answer Booklet

CHEMISTRY

Marking Key

Multiple-Choice Questions: ANSWERS

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

Section One: Multiple-choice **25% (25 Marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. 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.

---

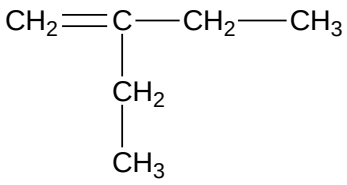
1. Which one of the following occurs as the atomic number increases for the Group 17 elements?

   (a) atomic radii decrease
   (b) melting points decrease
   (c) the tendency to gain electrons decreases
   (d) the elements become more reactive

2. The electron configuration for calcium is:

   (a) $1s^2\ 2s^8\ 3s^8\ 4s^2$
   (b) $1s^2\ 2s^2\ 2p^8\ 3s^2\ 3p^6$
   (c) $1s^2\ 2s^4\ 2p^6\ 3s^8$
   (d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

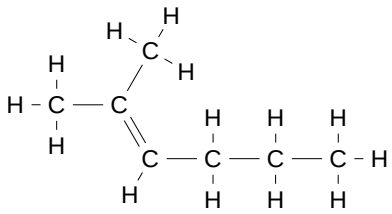
3. Which one of the following is the correct name for the compound shown below?



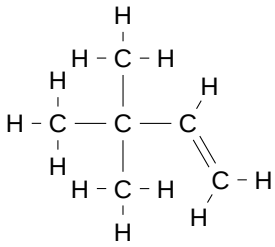
   (a) 3-ethylbut-1-ene
   (b) 3-methylpent-3-ene
   (c) 2-ethylbut-1-ene
   (d) hex-3-ene

4. Which one of the below is the structural formula for 2,2-dimethylhex-3-ene?

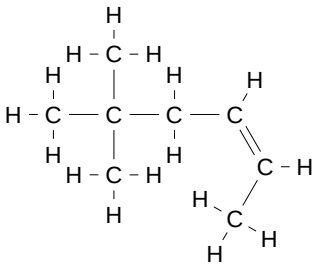
(a)



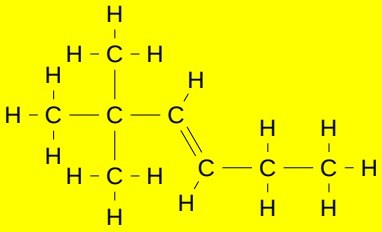
(c)



(b)



(d)



5. The coefficients required to balance the equation shown are respectively:

$$\_C_3H_8 + \_O_2 \rightarrow \_CO_2 + \_H_2O$$

(a)	1	5	3	4
(b)	1	2	1	4
(c)	2	5	6	8
(d)	2	5	6	4

6. Which one of these is the correct formula for barium phosphate?

(a) Ba_2PO_4
(b) $Ba_3(PO_4)_2$
(c) $Ba_2(PO_4)_3$
(d) $Ba_2(PO_3)_4$

7. Which one of these elements in Period 2 has the largest atomic radius?

(a) fluorine
(b) lithium
(c) carbon
(d) boron

8. When a gas is cooled in a sealed, rigid container, the

(a) pressure increases.
(b) volume and pressure decrease.
(c) pressure decreases.
(d) pressure might increase or decrease depending on the size of the gas particles.

9. Which one of the following elements will have the lowest electronegativity?

(a) Na
(b) Aℓ
(c) Si
(d) F

10. Which one of the following statements about elements in Groups 1 and 2 on the Periodic Table is **correct**?

(a) They can only become positively charged and form strong covalent molecules.
(b) They form negative ions because they have few valence electrons.
(c) They can either lose or share electrons to form positive ions or a strong metallic lattice.
(d) They can form positive ions because they have loosely held valence electrons.

11. What volume (in mL) of $O_2(g)$ is required to react with 25.0 mL of $H_2(g)$ at S.T.P. in the reaction shown below?

$$2\ H_2(g)\ +\ O_2(g)\ \rightarrow\ 2\ H_2O(\ell)$$

(a) 12.5
(b) 50.0
(c) 25.0
(d) 22.7

12. Silicon dioxide does not conduct electricity. Which of the following best explains this observation?

(a) It has delocalised valence electrons.
(b) It consists only of non-metal atoms.
(c) All of the valence electrons are involved in covalent bonds.
(d) It is a covalent network substance.

13. Which one of these has bonds that consist of pairs of electrons attracted to adjacent nuclei?

(a) sodium fluoride
(b) magnesium fluoride
(c) aluminium fluoride
(d) silicon tetrafluoride

14. Which one of these electron configurations represents a stable element?

(a) 2, 8, 1
(b) 2, 8, 7
(c) 2, 8, 8
(d) 2, 8, 8, 2

15. Which one of the following substances contains **only** covalent bonds?

(a) Fe_2O_3
(b) NH_4NO_3
(c) NaCℓ
(d) SiO_2

16. According to the following equation:

$$K_2SO_3 + 2\ HC\ell \rightarrow SO_2 + 2\ KC\ell + H_2O$$

what is the greatest number of moles of potassium chloride (KCℓ) that could be produced when 5 moles of potassium sulfite (K_2SO_3) are mixed with hydrochloric acid (HCℓ)?

(a) 2 moles
(b) 2.5 moles
(c) 5 moles
(d) 10 moles

17. Which one of the following aqueous solutions will form a white precipitate when a solution of potassium phosphate is added?

(a) sodium nitrate
(b) nickel (II) nitrate
(c) copper (II) nitrate
(d) aluminium nitrate

18. The chemical properties of an element are influenced mainly by the number of

(a) protons in the nucleus of its atoms.
(b) valence electrons of its atoms.
(c) occupied electron shells of its atoms.
(d) protons and neutrons in the nucleus of its atoms.

19. If salt crystals dissolve when added to a salt solution, it can be concluded correctly that the original solution was

(a) unsaturated
(b) saturated
(c) supersaturated
(d) either saturated or supersaturated

20. How many moles of carbonate ions are there in 4 moles of iron (III) carbonate?

(a) 4
(b) 6
(c) 8
(d) 12

21. Which of the following processes is endothermic?

(a) burning methane
(b) distilling ethanol
(c) condensing steam
(d) freezing water

22. What effect does changing the pH of a solution from 3 to 5 have on the hydrogen ion concentration?

(a) increases by a factor of four
(b) decreases by halving
(c) increases by a factor of 10
(d) decreases by a factor of 100

23. Which one of these correctly shows the products of a reaction between sulfuric acid and magnesium hydrogen carbonate?

(a) magnesium sulfate and water
(b) magnesium sulfate, hydrogen and carbon dioxide
(c) magnesium sulfate, water and sulfur dioxide
(d) magnesium sulfate, water and carbon dioxide

24. The combustion of natural gas (mainly methane) can be represented by:

$$CH_4\,(g) + 2\,O_2\,(g) \rightarrow CO_2\,(g) + 2\,H_2O\,(g) \qquad \Delta H = -890\ kJ\ mol^{-1}$$

Which one of the following would **decrease** the rate of the reaction?

(a) increasing the volume at constant temperature
(b) increasing the temperature at constant volume
(c) passing the gases over the surface of a catalyst
(d) increasing the concentration of reactants at constant temperature

25. Which one of the following observations can be explained in terms of hydrogen bonding?

(a) The boiling point of H_2S is greater than that of PH_3.
(b) The melting point of CH_4 is less than that of PH_3.
(c) The boiling point of H_2O is greater than that of H_2S.
(d) The melting point of HI is greater than that of NH_3.

End of Section One

Section Two: Short answer **35% (70 Marks)**

This section has **8** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

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.

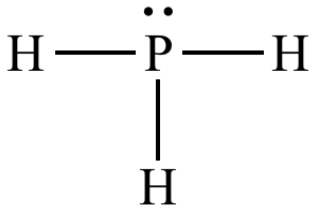
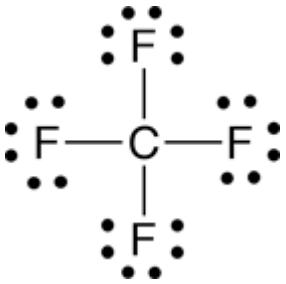
Question 26 **(14 marks)**

(a) Complete the table below by writing the name of the molecule and the name of the main intermolecular force between the molecules. (6)

Formula	Name	Main type of intermolecular force
CO	**Carbon monoxide**	**Dipole - dipole**
C_2H_6	**Ethane**	**Dispersion**
SO_2	**Sulfur dioxide**	**Dipole - dipole**

Description	Marks
Answers as above – mark independently	1 each
TOTAL	**6**

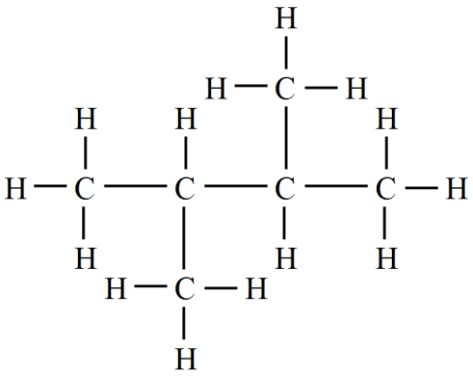
(b) Draw electron dot diagrams (Lewis structures), state the shape and polarity for each of the molecules below. (8)

Formula	Lewis structure	Shape	Is it polar?
PH_3		**Pyramidal**	**Yes**
CF_4		**Tetrahedral**	**No**

Description	**Marks**
Correct Lewis structure showing all bonding pairs and lone pairs	2 per molecule
Lewis structure with correct bonding pairs but incorrect / missing lone pairs OR Lewis structure with incorrect bonding pairs, but lone pairs drawn correctly for the molecule drawn	1 per molecule
Correct shape of molecule	1 per molecule
Molecules described as polar	1 per molecule
TOTAL	**8**

Question 27 **(8 marks)**

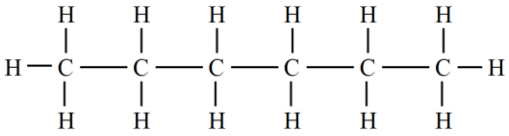
Consider the structure below.



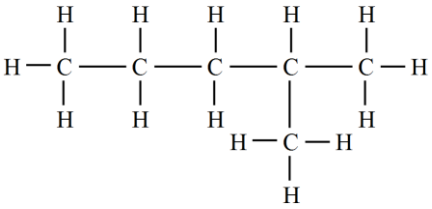
(a) Give the IUPAC **name** of this compound. (1)

Description	**Marks**
2,3-dimethylbutane Needs all numbers and letters as above, don't penalise incorrect dashes / commas.	1
TOTAL	**1**

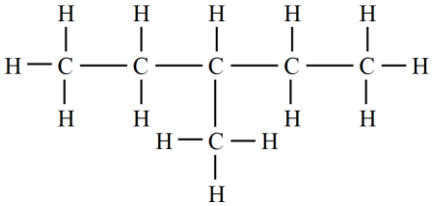
(b) **Draw** a full structural formula and give the IUPAC **name** for an isomer of the compound. (3)



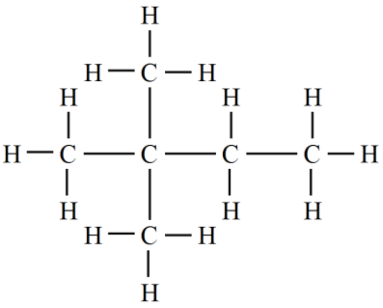
Hexane



2-methylpentane



3-methylpentane



2,2-dimethylbutane

No other isomers are possible – answer must be one of these four.

Description	Marks
Molecule attempted is one of the four options shown above	1
Molecule drawn shows all atoms and all bonds correctly	1
Name matches molecule drawn (Error carried forward OK here)	1
TOTAL	**3**

(c) Write balanced equations for the reactions of the compound shown in part (a), C_6H_{14}, with the following substances: (4)

(i) Excess oxygen.

$C_6H_{14} + 9\ ½\ O_2 \rightarrow 6\ CO_2 + 7\ H_2O$
OR
$2\ C_6H_{14} + 19\ O_2 \rightarrow 12\ CO_2 + 14\ H_2O$

(ii) Limited amount of chlorine, in the presence of UV light.

$C_6H_{14} + Cl_2 \rightarrow C_6H_{13}Cl + HCl$

NB: With limited chlorine, the most likely outcome is single substitution, however if double substitution etc is drawn, with one mole of Cl_2 and HCl for each hydrogen substituted, this can be awarded credit. MAX number of hydrogens substituted = 3.

Description	Marks
Equation has correct species	1 each
Equation is correctly balanced	1 each
TOTAL	**4**

Question 28 **(6 marks)**

Complete the following table describing some isotopes.

Name of Species	Symbol	Number of protons	Number of neutrons	Number of electrons	Atomic number	Mass number
	^{197}Au	**79**	**118**	**79**	**79**	**197**
Carbon-13	**^{13}C**	**6**	**7**	6	**6**	**13**
	N^{3-}	**7**	**7**	**10**	7	14

Description	Marks
One mark for each column correct	1 each
TOTAL	**6**

Question 29 **(9 marks)**

The solubility of copper (II) chloride ($CuC\ell_2.H_2O$) is approximately 75.7 g/100 mL at 25 ^oC.

(a) Determine the concentration in mol L^{-1} of a solution made by completely dissolving 45.0 g of $CuC\ell_2.H_2O(s)$ in 120 mL of water at 25 ^oC. (assume no volume change) (2)

Description	**Marks**
n ($CuCl_2.H_2O$) = m / M_r = 45.0 / 152.466 = 0.295 mol	1
c = n / v = 0.295 / 0.120 = 2.46 mol L^{-1} (sig figs not penalised)	1
TOTAL	**2**

(b) Is this solution saturated, unsaturated or supersaturated? Explain your answer. (2)

Description	**Marks**
Unsaturated	1
Any clear and reasonable justification using **data** Eg: Less mass dissolved in 120 mL than would be required to make 100 mL of saturated solution.	1
TOTAL	**2**

(c) Describe the appearance of this solution. (2)

Description	**Marks**
Clear / solution (solution implies clear)	1
Blue	1
TOTAL	**2**

(d) Describe all the types of bonding present between particles in the solution of copper (II) chloride. (3)

Description	**Marks**
Ion – dipole bonding between ions and water	1
Hydrogen bonding between water molecules	1
Dispersion forces between all particles Can also include dipole – dipole forces, but not required for mark	1
TOTAL	**3**

Question 30 **(7 marks)**

20.0 mL of 5.00 x 10^{-2} mol L^{-1} lead (II) nitrate solution is added to an excess of sodium iodide solution.

(a) Write a balanced ionic equation, with state symbols, for the reaction that occurs when they are mixed. (2)

Pb^{2+} (aq) + 2 I^- (aq) → PbI_2 (s)

Description	Marks
Completely correct ionic equation with state symbols	2
Correct balanced molecular equation with state symbols OR Incorrectly balanced ionic equation with state symbols OR Correct balanced ionic equation without all state symbols	1
TOTAL	**2**

(b) Describe in full what you would observe in the reaction, including any:

- Colours
- Odours
- Precipitates (give the colour)
- Gases evolved (give the colour or describe as colourless) (2)

Description	Marks
Reactants described – two clear colourless solutions	1
Produce **yellow precipitate**	1
TOTAL	**2**

(c) Calculate the mass of solid product. (3)

Description	Marks
n ($Pb(NO_3)_2$) = c v = 5 x 10^{-2} x 0.02 = 1 x 10^{-3} mol	1
n (PbI_2) = n ($Pb(NO_3)_2$) = 1 x 10^{-3} mol	1
m (PbI_2) = n M_r = 1 x 10^{-3} x 461 = 0.461 g (sig figs not penalised)	1
TOTAL	**3**

Question 31 **(8 marks)**

Calculate the pH of the following solutions:

(a) 1.45 x 10^{-3} mol L^{-1} nitric acid (1)

Description	Marks
pH = - log $[H^+]$ = - log (1.45 x 10^{-3}) = 2.84 (sig figs not penalised)	1
TOTAL	**1**

(b) 0.0672 mol L^{-1} potassium hydroxide solution (2)

Description	Marks
$[H^+] = K_w / [OH^-] = 10^{-14} / 0.0672 = 1.49 \times 10^{-13}$ mol L^{-1}	1
pH = - log $[H^+]$ = - log (1.49 x 10^{-13}) = 12.8 (sig figs not penalised)	1
TOTAL	**2**

(c) A solution made by mixing 15.0 mL of 2.25 x 10^{-3} mol L^{-1} sulfuric acid and 45.0 mL of 1.75 x 10^{-3} mol L^{-1} barium hydroxide solution, giving your answer to the appropriate number of significant figures. (5)

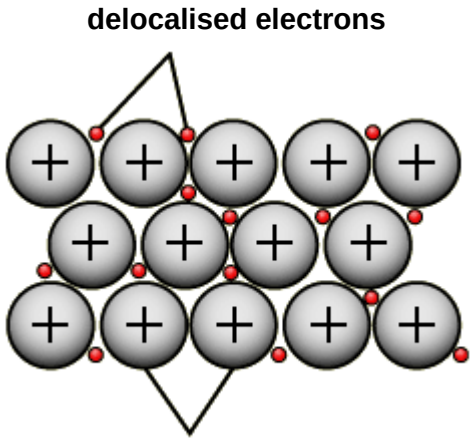
Description	Marks
n (H_2SO_4) = c v = 2.25 x 10^{-3} x 0.015 = 3.375 x 10^{-5} mol n (H^+) = 2 n (H_2SO_4) = 6.75 x 10^{-5} mol	1
n ($Ba(OH)_2$) = c v = 1.75 x 10^{-3} x 0.045 = 7.875 x 10^{-5} mol n (OH^-) = 2 n ($Ba(OH)_2$) = 1.575 x 10^{-4} mol	1
OH^- in excess: n (OH^-) excess = 1.575 x 10^{-4} - 6.75 x 10^{-5} = 9 x 10^{-5} mol	1
$[OH^-]$ = n / v = 9 x 10^{-5} / 0.060 = 1.5 x 10^{-3} mol L^{-1} $[H^+] = K_w / [OH^-] = 10^{-14} / 1.5 \times 10^{-3} = 6.67 \times 10^{-12}$ mol L^{-1}	1
pH = - log $[H^+]$ = - log (6.67 x 10^{-12}) = 11.2 Answer must be to 3 sig figs	1
TOTAL	**5**

Question 32 **(7 marks)**

Potassium is a highly reactive metal, which was first isolated from potash, the ashes of plants, from which its name derives. It is always found in nature as part of an ionic salt, such as potassium chloride, which is found in sea water. Potassium chloride is also produced by the violently exothermic reaction of potassium metal with chlorine gas.

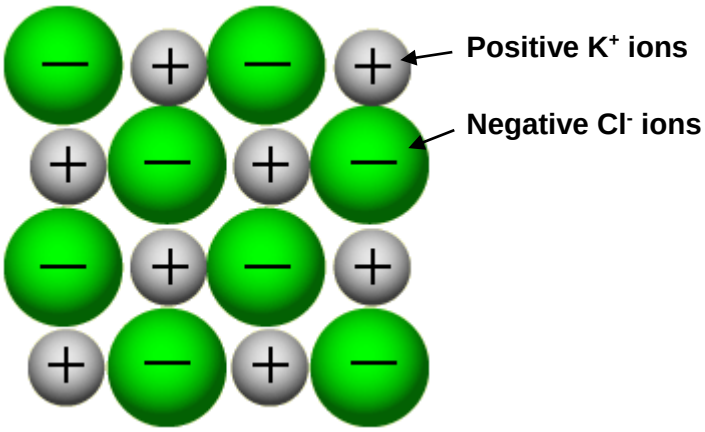
$$2\ K\ (s) + C\ell_2\ (g) \rightarrow 2\ KC\ell\ (s)$$

(a) Using a labelled diagram, describe the bonding present in solid potassium. (3)



Description	**Marks**
Particles arranged in a regular lattice (drawn or labelled)	1
Positively charged potassium ions drawn and labelled (can be labelled + as long as it says somewhere that they are K^+ ions)	1
Delocalised electrons drawn and labelled	1
TOTAL	**3**

(b) Using a labelled diagram, describe the bonding present in solid potassium chloride. (2)



Description	Marks
Particles arranged in a regular lattice	1
Potassium and chloride ions in an alternating pattern, and labelled with at least their charge	1
TOTAL	**2**

(c) Explain why solid potassium can conduct electricity, whereas solid potassium chloride cannot. (2)

Description	Marks
Metal: Delocalised electrons can flow through structure to carry current	1
Ionic solid: **ions** cannot move / fixed in lattice so cannot carry current	1
TOTAL	**2**

Question 33 **(11 marks)**

A group of students decided to carry out experiments to investigate the following reaction:

$$NiCO_3\,(s) + 2\,HC\ell\,(aq) \rightarrow NiC\ell_2\,(aq) + CO_2\,(g) + H_2O\,(\ell)$$

(a) Describe in full what they would observe in the reaction, including any:

- Colours
- Odours
- Precipitates (give the colour)
- Gases evolved (give the colour or describe as colourless) (3)

Description	**Marks**
Green solid (combined with clear colourless solution)	1
Produces **green solution**	1
Bubbles of colourless gas / fizzing / effervescence	1
TOTAL	**3**

(b) In the first experiment, Annie measured out exactly 15.0 g of nickel (II) carbonate. Calculate the volume of 2.00 mol L^{-1} $HC\ell$ solution that will react completely with 15.0 g of $NiCO_3\,(s)$. (3)

Description	**Marks**
n ($NiCO_3$) = m / M_r = 15.0 / 118.7 = 0.126 mol	1
n (HCl) = 2 n ($NiCO_3$) = 0.253 mol	1
vol = n / c = 0.253 / 2 = 0.126 L (126 mL) (sig figs not penalised)	1
TOTAL	**3**

(c) In the second experiment, Sid started with 10.0 mL of 2.00 mol L^{-1} hydrochloric acid. Calculate the concentration of $NiC\ell_2$ (aq) in mol L^{-1} produced when excess solid $NiCO_3$ reacts with 10.0 mL of 2.00 mol L^{-1} $HC\ell$ (aq). (assume no change in volume)

(3)

Description	**Marks**
n (HCl) = c v = 2 x 0.01 = 0.02 mol	1
n ($NiCl_2$) = ½ n (HCl) = 0.01 mol	1
c = n / v = 0.01 / 0.01 = 1 mol L^{-1} (sig figs not penalised)	1
TOTAL	**3**

(d) In the third experiment, Phil worked out the mass of 3.00 moles of nickel (II) carbonate. Calculate the volume of CO_2 (g) produced at S.T.P. when 3.00 moles of $NiCO_3$ (s) completely reacts in an excess of $HC\ell$ (aq). (2)

Description	**Marks**
n (CO_2) = n ($NiCO_3$) = 3 mol	1
v = n x 22.71 = 3 x 22.71 = 68.1 L (sig figs not penalised)	1
TOTAL	**2**

End of Section Two

Section Three: Extended answer **40% (80 Marks)**

This section contains **5** questions. You must 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. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

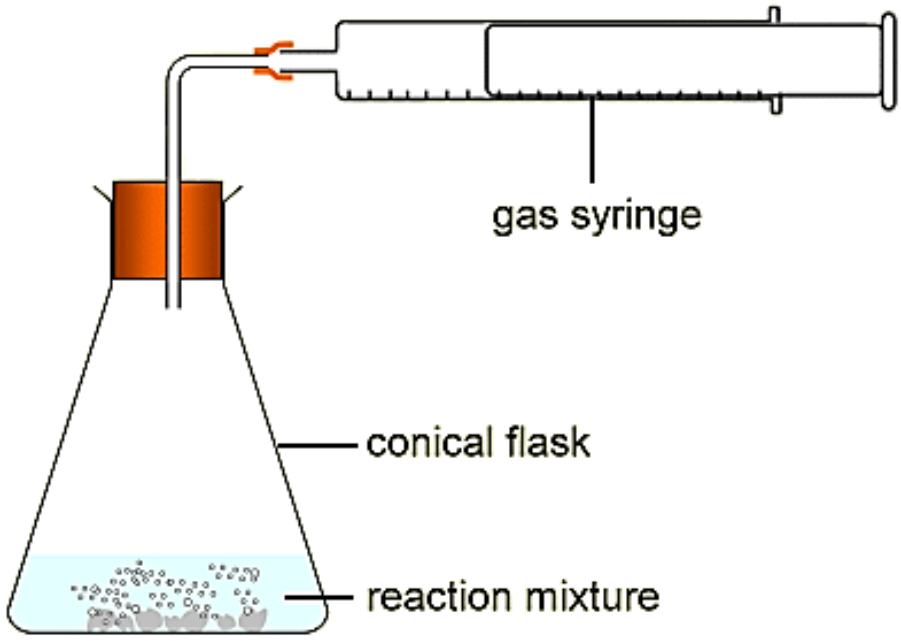
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- 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: 70 minutes.

Question 34 **(20 marks)**

A class of students was asked to investigate factors affecting the rate of the reaction between acids and magnesium. The reaction equipment is shown below.



Some students carried out an investigation into the effect of concentration of nitric acid on the rate of this reaction, by combining 20.0 mL of dilute nitric acid of various concentrations, with 0.10 g of magnesium ribbon.

(a) Write a balanced equation for this reaction, with state symbols, and give observations for the reaction, including any:

- Colours
- Odours
- Precipitates (give the colour)
- Gases evolved (give the colour or describe as colourless) (3)

$Mg\ (s) + 2\ H^+\ (aq) \rightarrow Mg^{2+}\ (aq) + H_2\ (g)$

Description	**Marks**
Completely correct ionic equation with state symbols	2
Correct balanced molecular equation with state symbols OR Incorrectly balanced ionic equation with state symbols OR Correct balanced ionic equation without all state symbols	1
Grey solid (combined with clear colourless solution produces **colourless gas / bubbles / effervescence etc** (both bold parts required for mark)	1
TOTAL	**3**

The group chose to measure the total volume of gas produced and the time it took to be produced. Their results are shown in the table on the next page.

(b) Explain why each of the trials produced about the same volume of gas. (3)

Description	**Marks**
Nitric acid must be in excess / magnesium must be the limiting reagent	1
Any reasonable justification of above – mass of Mg is constant, vol of acid constant but conc changes so moles of acid changes	1
Volume of hydrogen depends on amount of magnesium used so is the same in each trial (or any clear link between amount of Mg and vol of H_2)	1
TOTAL	**3**

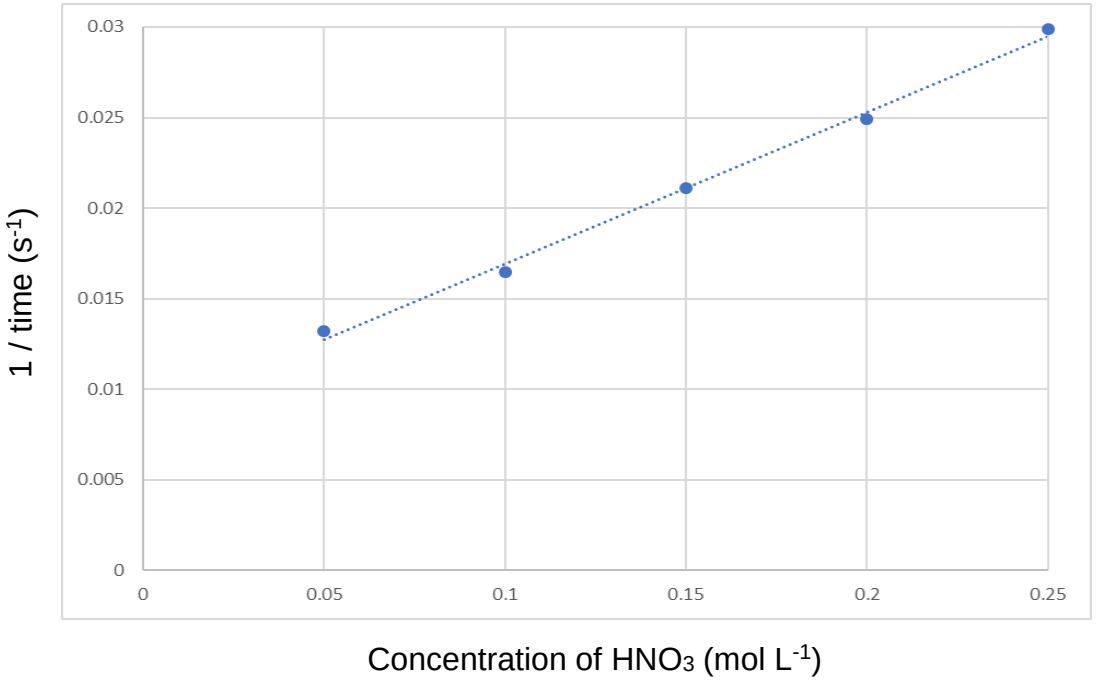
The group's experimental results are shown below.

Trial	Concentration of HNO_3 used (mol L^{-1})	Volume of HNO_3 used (mL)	Volume of gas produced (mL)	Time taken (s)	1 / time (s^{-1})
1	0.25	100	30.5	33.4	**0.0299**
2	0.20	100	27.3	40.1	**0.0249**
3	0.15	100	28.4	47.4	**0.0211**
4	0.10	100	29.7	60.5	**0.0165**
5	0.05	100	28.1	75.8	**0.0132**

(c) In the table above, complete the column for the values of 1 / time taken, giving your answers to **three** significant figures. (1)

Description	Marks
All values correct as above, and to 3 sig figs	1
TOTAL	**1**

(d) On the grid below, draw a graph of 1 / time against concentration of nitric acid. (5)



Description	Marks
Axes the right way round (see above)	1
Concentration axis has label, units, even scale	1
1 / time axis has label, units, even scale	1
Points plotted accurately and clearly visible	1
Straight line of best fit drawn with a ruler	1
TOTAL	**5**

(e) Use collision theory to explain the effect of increasing the concentration of nitric acid on the rate of this reaction. (4)

Description	Marks
More particles of nitric acid in a given volume	1
Frequency of collisions between reactants increases	1
Frequency / number of successful collisions increases	1
Rate of reaction increases	1
TOTAL	**5**

Another group of students in the same class carried out their investigation using the same concentrations of ethanoic acid, CH_3COOH, instead of nitric acid.

(f) Describe how their results would be different, and explain why this is the case. (4)

Description	Marks
Time taken for reaction is longer (**not** less gas in a given time – this is not what the method measures)	1
Ethanoic acid is a weak acid / only a small proportion of molecules are ionised	1
Concentration of H^+ is lower	1
Rate of reaction is slower	1
TOTAL	**4**

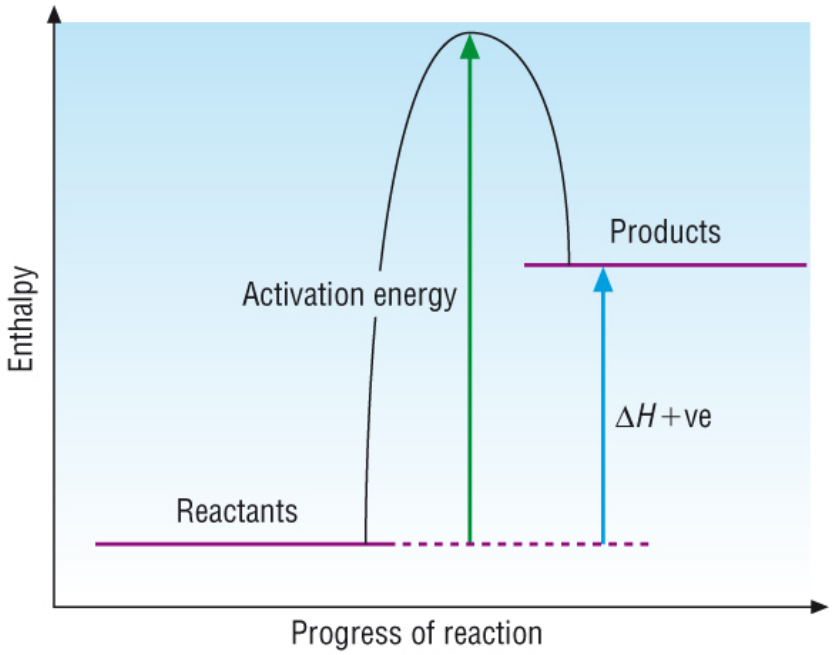
Question 35 **(15 marks)**

Photosynthesis is the process by which plants, some algae and some bacteria use energy from sunlight to produce glucose from carbon dioxide and water. This glucose can be used for cellular respiration, and oxygen is formed in the reaction.

$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2 \qquad \Delta H = +2803\ kJ\ mol^{-1}$$

The green pigment chlorophyll absorbs blue and red light, and is present in high quantities in cells that do photosynthesis. Plants can photosynthesise across a wide temperature range, providing they have visible light of the right wavelengths and sufficient intensity.

(a) Draw an enthalpy profile diagram for this chemical reaction, and label important features. (5)



Description	Marks
Axes labelled (Enthalpy **not** energy, and progress / time etc)	1
Reactants and products labelled (formulae can be used as well or instead, but would need coefficients)	1
Reaction profile drawn (transition state not required but can be included)	1
Activation energy labelled	1
Enthalpy change labelled (value not required)	1
TOTAL	**5**

(b) Is this reaction endothermic or exothermic? How do you know? What does this tell you about the relative bond energies of the reactants and products in the reaction? (5)

Description	**Marks**
Endothermic	1
As the enthalpy change is positive	1
Energy is absorbed from the surroundings	1
Comparison of bond energies, making clear where bonds are broken or made Eg: Energy needed to **break** bonds in reactants is **greater than** energy released when **forming** bonds in the products	2
Comparison of bond energies, but breaking / making not clear	1
TOTAL	**5**

(c) The rate of photosynthesis varies significantly with the light and weather conditions. With reference to activation energy,

- explain why plants cannot photosynthesise at night.
- predict how the rate of photosynthesis during the day would be affected by temperature conditions.
- explain why changing the temperature affects the rate of photosynthesis. (5)

Description	**Marks**
Photosynthesis cannot take place at night as there is not enough light present	1
Without light, cannot overcome activation energy for the reaction	1
Rate of photosynthesis increases as temperature increases	1
Higher temperature increases (average) energy of molecules	1
Greater proportion of collisions are successful / have energy in excess of activation energy etc	1
TOTAL	**5**

Question 36 **(8 marks)**

Hydrogen halides are gaseous molecular compounds that can act as acids when dissolved in water, with varying strength. They can also be used to make halogenated organic compounds, which are precursors to many useful organic products, such as medicines and polymers.

The boiling points of the hydrogen halides are given below. Use the information in the table, and your understanding of intermolecular forces, to answer the questions that follow.

Hydrogen halide	Boiling point (K)
HF	292
HCℓ	188
HBr	206
HI	238

(a) Explain why hydrogen fluoride's boiling point is significantly higher than the boiling points of the other hydrogen halides. (3)

Description	Marks
Hydrogen fluoride forms hydrogen bonds whereas the others can't	1
Hydrogen bonds make the intermolecular bonding in HF stronger than the intermolecular bonding in the others	1
Greater amount of energy needed to overcome stronger intermolecular bonds so boiling point is higher	1
TOTAL	**3**

(b) Explain the trend observed in the boiling points of hydrogen chloride, hydrogen bromide and hydrogen iodide (exclude hydrogen fluoride). Refer to all types of intermolecular bonds present in your answer. (5)

Description	**Marks**
HCl, HBr and HI all form dipole – dipole forces (These get weaker down the group due to decreasing difference in polarity – but this is not required)	1
All three also form dispersion forces	1
As you go down the group, dispersion forces get stronger due to increasing number of electrons in the molecule	1
The **sum** of the dipole – dipole and dispersion forces is what must be overcome for the substance to boil	1
Boiling point increases down the group therefore the increasing strength of dispersion forces must be responsible for this trend	1
TOTAL	**5**

Question 37 **(19 marks)**

Western Australia has deposits of a wide range of metal ores, and the mining industry is one of the largest commodity sectors in Australia. Mining and extraction of metals involves large volumes of water, which can be contaminated with heavy metal salts. These ions must be removed before the mine water can be reused or released to the environment.

Mine water may contain valuable amounts of gold and other precious metals, so it is often economically viable to extract these substances from the solution. There are a variety of methods of removing dissolved salts from water; including precipitation then filtration, and distillation.

(a) Describe the purification of mine water by distillation. Include the physical properties of the components that allow this method to work. (3)

Description	**Marks**
Mine water is heated to (at least) 100^{o}C so that the water boils	1
Steam is collected and condensed	1
Ionic salts are left behind as their boiling points are much higher than that of water	1
TOTAL	**3**

(b) Does distillation allow dissolved gases to remain in the water? Explain your answer. (2)

Description	**Marks**
Distillation removes dissolved gases from water	1
The gases come out of solution but do not condense with the water (NB: If the water is left to stand, gases will re-dissolve over time)	1
TOTAL	**2**

(c) Explain why distillation would not be suitable as a method to purify mine water on a industrial scale. (1)

Description	**Marks**
Large energy / fuel / electricity / heat requirement	1
TOTAL	**1**

(d) Explain why laboratory filtration is not able to separate the dissolved ions from mine water. (2)

Description	Marks
Dissolved ions are small enough to pass through the pores in filter paper	1
Filtration can only remove solids / larger particles / etc	1
TOTAL	**2**

Water from gold mining operations can contain measurable quantities of gold (III) chloride in solution. The Au^{3+} ions can be tested for by a precipitation reaction with sodium carbonate solution.

(e) Write a balanced equation with state symbols for this precipitation reaction. (2)

$2\ Au^{3+}\ (aq) + CO_3^{2-}\ (aq) \rightarrow Au_2(CO_3)_3\ (s)$

Description	Marks
Completely correct ionic equation with state symbols	2
Correct balanced molecular equation with state symbols OR Incorrectly balanced ionic equation with state symbols OR Correct balanced ionic equation without all state symbols	1
TOTAL	**2**

(f) Determine the gold (III) chloride concentration, in mol L^{-1}, if 2.50×10^2 mL of mine water produced 4.18×10^{-3} g of precipitate. (3)

Description	Marks
n $(Au_2(CO_3)_3)$ = m / M_r = 4.18×10^{-3} / 574.03 = 7.28×10^{-6} mol	1
n (Au) = 2 n $(Au_2(CO_3)_3)$ = 1.46×10^{-5} mol	1
c = n / v = 1.46×10^{-5} / 0.25 = 5.83×10^{-5} mol L^{-1} (sig figs not penalised)	1
TOTAL	**3**

(g) Express the concentration of gold (III) ions in parts per million by mass. You can assume that 2.50×10^2 mL of solution has a mass of 2.50×10^2 g. (3)

Description	Marks
m (Au) = n A_r = $1.46 \times 10^{-5} \times 197 = 2.87 \times 10^{-3}$ g	1
ppm (Au) = m (Au) in mg / m (sample) in kg OR: any other valid method to find ppm	1
ppm (Au) = 2.87 / 0.25 = 11.5 ppm	1
TOTAL	**3**

Gold has one stable isotope, ^{197}Au, and 18 radioactive isotopes. The relative proportion of isotopes present can be used to identify the source of a sample of gold.

Gold produced by the Granny Smith mine in Kalgoorlie was analysed by a mass spectrometer. Three isotopes of gold were present, in the proportions below.

Isotope	Percentage abundance
^{195}Au	2.564 %
^{196}Au	1.136 %
^{197}Au	96.30 %

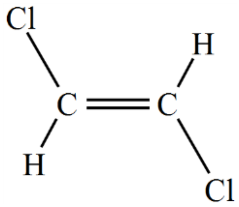
(h) Calculate the relative atomic mass of this sample of gold, expressing your answer to **four** significant figures. (3)

Description	Marks
A_r = (2.564 x 195) + (1.136 x 196) + (96.30 x 197) / 100	1
A_r = 196.9	1
Answer given to 4 sig figs	1
TOTAL	**3**

Question 38 **(18 marks)**

Both *cis*-1,2-dichloroethene and *trans*-1,2-dichloroethene, and sometimes even a mixture of the compounds, are used as solvents in the production of waxes, resins and polymers, and also as refrigerants. Unfortunately, they are toxic substances, and so should not be released into the environment.

(a) Draw the full structural formula of *trans*-1,2-dichloroethene. Use your diagram to help you explain the difference between the structural and geometric isomers of this compound. (4)

Description	**Marks**
Trans-1,2-dichloroethene drawn correctly with roughly accurate bond angles 	1
Structural isomers have the same molecular formula but atoms are bonded in a different order	1
Geometric isomers have the same molecular formula, atoms bonded in the same order, but different arrangement in space (around the C=C double bond)	1
Isomers of **this compound** used to support explanation	1
TOTAL	**4**

(b) The manufacture of the isomers of 1,2-dichloroethene begins with one hydrocarbon, that is analysed to be 85.6 % carbon by mass. Calculate the empirical formula of the hydrocarbon. (4)

Description	**Marks**
% H = 100 – 85.6 = 14.4%	1
Assuming sample of 100 g of hydrocarbon, n (C) = 7.1274 n (H) = 14.2857 (Can award marks for samples of different sizes)	1
Clearly shown ration of elements 1 : 2	1
Empirical formula CH_2	1
TOTAL	**4**

(c) A sample of the gaseous hydrocarbon has a volume of 1.182 L at S.T.P and a mass of 1.460 g. Work out the molecular formula of the hydrocarbon. (4)

Description	**Marks**
n = m / 22.71 = 1.182 / 22.71 = 0.0521 mol	1
M_r = m / n = 1.460 / 0.0521 = 28.1	1
M_r / M_{EF} = 28.1 / 14.026 ≈ 2	1
Molecular formula C_2H_4	1
TOTAL	**4**

During the manufacture of the isomers of 1,2-dichloroethene, samples of the reactants and products are frequently tested, to ensure that the reaction is giving the desired products. One of the tests carried out on the hydrocarbon reactant and the range of products is a test for unsaturation.

(d) Explain the difference between a saturated and an unsaturated hydrocarbon.
Suggest a test that could be used to establish whether the substances are saturated or unsaturated, and give expected observations that would confirm saturation and unsaturation.
Write a balanced equation for the reaction that would take place in the test, for one of the compounds discussed in this question. (6)

Description	**Marks**
Saturated hydrocarbons contain as many hydrogen atoms as possible on the carbon chain	1
Unsaturated hydrocarbons contain fewer hydrogen atoms than maximum for the carbon chain	1
Test for unsaturation: shake with bromine water / solution (**not** pure Br_2) (Also accept shake with iodine solution)	1
Saturated substances: mixture remains **orange**	1
Unsaturated substances: mixture decolourises / turns colourless / fades	1
Any correct example of an **addition** reaction between one of the examples and Br_2. Can use molecular or structural formulae. Eg: $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$	1
TOTAL	**6**