



Iona Presentation College

**Year 12 Chemistry Examination
Semester One, 2000**

Name: _____

STRUCTURE OF THE PAPER

Part	Format	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (Approx.)/ Minutes
1	Multiple Choice	30	ALL	(30%)	55
2	Short Answers	11	ALL	(35%)	60
3	Calculations	5	ALL	(25%)	45
4	Extended Answers	3	1	(10%)	20

Total mark for paper = (100%)

INSTRUCTIONS TO CANDIDATES

Reading Time : The examiners recommend that candidates spend the reading time mainly reading the Instructions to Candidates and Parts 2, 3 and 4.

Part 1 — Multiple Choice

Use a 2B, B or HB pencil to answer on the separate Multiple Choice Answer Sheet. **Do not** use a ballpoint or ink pen.

If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will **not** be deducted for incorrect answers.

FEEL FREE TO WRITE OR DO WORKING ON THE QUESTION PAPER; many students who score high marks in the Multiple Choice Section do this.

Parts 2, 3 and 4

Use a ballpoint or ink pen. **Do not** answer in pencil. Write your answers in this Question/ Answer Booklet.

At the end of the examination make sure that your Student Number is on your Question/ Answer Booklet and on your separate Multiple Choice Answer Sheet.

Questions containing specific instructions to show working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will not be awarded full marks.

CHEMICAL EQUATIONS

For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $\text{Ag}^+(\text{aq})$], **molecules** [for example $\text{NH}_3(\text{g})$, $\text{NH}_3(\text{aq})$, $\text{CH}_3\text{COOH}(\text{l})$, $\text{CH}_3\text{COOH}(\text{aq})$] or **solids** [for example $\text{BaSO}_4(\text{s})$, $\text{Cu}(\text{s})$, $\text{Na}_2\text{CO}_3(\text{s})$].

PART 1

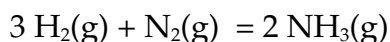
Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet provided. This part carries 30 marks.

- Which one of the following has a noble-gas electron configuration?
 - Na
 - H
 - Fe^{3+}
 - H^-
- In which of the following substances would you expect the bonding to be most ionic?
 - Ice
 - Solid ammonia
 - Solid lead bromide
 - Solid silicon dioxide
- An element has the first five successive ionisation energies
0.6 1.8 2.8 11.6 14.8 MJ mol^{-1}
Which one of the following is it?
 - Aluminium
 - Argon
 - Calcium
 - Carbon
- Which of the following statements best explains the fact that paraffin wax (a long-chain hydrocarbon) is almost insoluble in water?
 - Wax molecules are more stable than water molecules.
 - Carbon-carbon bonds in wax are not broken by hydrogen-bonding to water molecules.
 - Wax-water molecular attractions are weaker than water-water attractions.
 - Wax-wax molecular attractions are weaker than water-water attractions.
- Which one of the following has linear molecules at 25°C ?
 - CS_2
 - CaCl_2
 - H_2S
 - SiO_2
- In which of the following aqueous solutions is there the greatest number of ions?
 - 1.00 L of $2.00 \text{ mol L}^{-1} \text{CH}_3\text{COONa}$ solution.
 - 1.00 L of $2.00 \text{ mol L}^{-1} \text{MgSO}_4$ solution.
 - 1.00 L of $3.00 \text{ mol L}^{-1} \text{CH}_3\text{COOH}$ solution.

(d) 1.00 L of 2.00 mol L⁻¹ Na₂CO₃ solution.

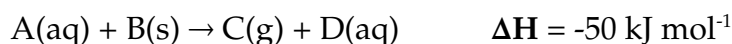
7. In which one of the following pairs are both elements more electronegative than carbon?
- (a) B and Li
 - (b) B and N
 - (c) Ge and Si
 - (d) N and O

8. Which one of the following statements about the following reversible reaction is TRUE?



(Equilibrium constant = K . Heat of reaction = ΔH)

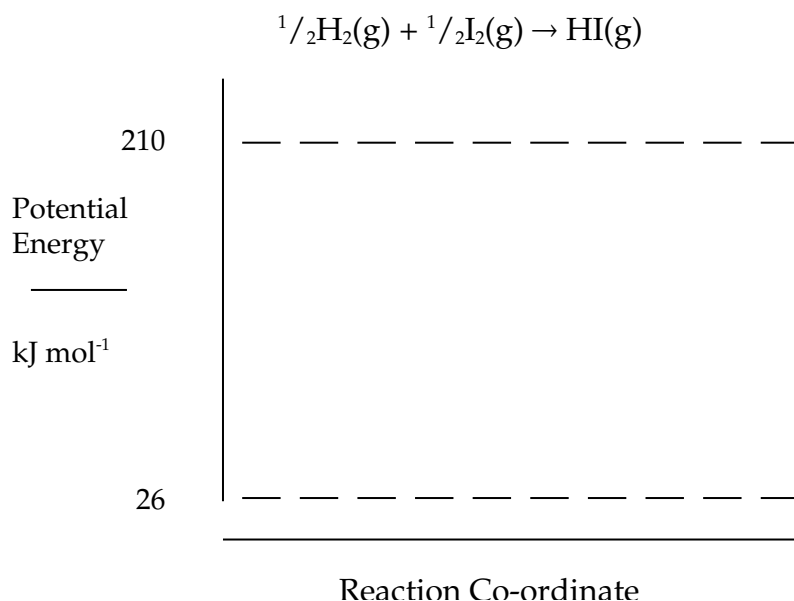
- (a) $K = \frac{[\text{H}_2]^3 [\text{N}_2]}{[\text{NH}_3]^2}$
 - (b) K is constant under all conditions.
 - (c) A catalyst increases the yield of ammonia by increasing ΔH .
 - (d) Ammonia is being formed when the gases are at equilibrium.
9. For the chemical reaction:



Which one of the following actions would increase the rate of the reaction?

- (a) Using the same mass of B, but in larger lumps.
- (b) Increasing the pressure inside the reaction vessel.
- (c) Heating the reaction mixture.
- (d) Increasing the volume of the reaction mixture.

10. Consider the following potential energy diagram for the reaction of hydrogen with iodine in the gas phase:



For the decomposition of hydrogen iodide (**REVERSE** of the above reaction) what are the values of activation energy E_A and heat of reaction ΔH ?

- (a) $E_A = 210 \text{ kJ mol}^{-1}$; $\Delta H = 26 \text{ kJ mol}^{-1}$
 - (b) $E_A = 184 \text{ kJ mol}^{-1}$; $\Delta H = -26 \text{ kJ mol}^{-1}$
 - (c) $E_A = -184 \text{ kJ mol}^{-1}$; $\Delta H = -26 \text{ kJ mol}^{-1}$
 - (d) $E_A = 184 \text{ kJ mol}^{-1}$; $\Delta H = 26 \text{ kJ mol}^{-1}$
11. Which of the following best explains why sodium chloride is almost insoluble in ethanol?
- (a) Sodium and chloride ions do not form strong enough interactions with ethanol to disrupt the sodium chloride crystal lattice and overcome the van der Waals forces in the ethanol.
 - (b) Ethanol cannot interact with sodium ions or chloride ions, and hence sodium chloride will not dissolve.
 - (c) Although both sodium chloride and ethanol are polar they are not similar enough for the "like dissolves like" rule to apply.
 - (d) Sodium chloride and ethanol are both highly stable compounds and therefore do not react easily.

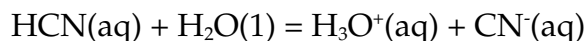
12. In the titration of a strong acid against an alkali, which of the following statements **BEST** describes the equivalence point?
- (a) The point at which the rate of the forward reaction equals the rate of the reverse reaction.
 - (b) The point at which the same number of moles of acid and alkali have been put into the flask.
 - (c) The point at which the first sign of a colour change is seen.
 - (d) The point at which the same number of moles of H^+ and OH^- have reacted.
13. Which of the following species does **NOT** have the same electronic configuration as an oxide ion, O^{2-} ?
- (a) A nitride ion, N^{3-}
 - (b) A sodium ion, Na^+
 - (c) An aluminium ion, Al^{3+}
 - (d) A sulfide ion, S^{2-}
14. The pH of an aqueous solution is found to be 12.00. Which of the following solutions is consistent with this observation?
- (a) $5.00 \times 10^{-3} \text{ mol L}^{-1}$ sulfuric acid.
 - (b) $1.00 \times 10^{-12} \text{ mol L}^{-1}$ sodium hydroxide.
 - (c) $5.00 \times 10^{-1} \text{ mol L}^{-1}$ calcium hydroxide.
 - (d) $1.00 \times 10^{-2} \text{ mol L}^{-1}$ potassium hydroxide.
15. In the third row of the periodic table, the ionization energy of successive elements tends to increase when moving from left to right along the row. Which of the following statements best explains this general trend?
- (a) The atomic size is increasing.
 - (b) The number of electrons is increasing.
 - (c) The atomic mass is increasing.
 - (d) The number of protons is increasing.
16. In which one of the following cases will a precipitate be formed when 0.1 mol L^{-1} solutions of the two compounds are mixed together at 25°C ?
- (a) Sodium sulfate and copper chloride.
 - (b) Lead nitrate and potassium iodide.
 - (c) Ammonium chloride and sodium hydroxide.
 - (d) Sodium phosphate and ammonium carbonate.
17. How many *d*-electrons are present in a krypton atom, ${}_{36}\text{Kr}$, in its ground state?
- (a) 0
 - (b) 10
 - (c) 18

(d) 28

18. Which one of the following molecules is planar?

- (a) NH_3
- (b) BCl_3
- (c) C_2H_6
- (d) C_3H_6

19. Consider the following reaction:



Which of the species in the equation shown is/are acting as bases?

- (a) $\text{HCN}(\text{aq})$ and $\text{H}_2\text{O}(\text{l})$
- (b) $\text{HCN}(\text{aq})$ and $\text{H}_3\text{O}^+(\text{aq})$
- (c) $\text{HCN}(\text{aq})$ and $\text{CN}^-(\text{aq})$
- (d) $\text{H}_2\text{O}(\text{l})$ and $\text{CN}^-(\text{aq})$.

20. Which one of the following properties would **NOT** be exhibited by niobium (atomic number 41)?

- (a) It is an electrical insulator.
- (b) Many of its compounds are coloured.
- (c) It can exhibit various oxidation states in its salts.
- (d) It can take part in the formation of complex ions.

21. In which of the following pairs do both atoms contain **valence-shell** electrons in d-sublevels?

- (a) Sn and Fe
- (b) S and Al
- (c) Cs and In
- (d) Cu and Fe

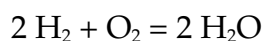
22. Some solid barium carbonate is added to dilute nitric acid. Which of the following equations **best** represents the **reaction** that takes place?

- (a) $\text{Ba}_2\text{CO}_3 + 2 \text{HNO}_3 \rightarrow 2 \text{BaNO}_3 + \text{H}_2\text{O} + \text{CO}_2$
- (b) $\text{BaCO}_3 + 2 \text{H}^+ \rightarrow \text{Ba}^{2+} + \text{H}_2\text{O} + \text{CO}_2$
- (c) $\text{Ba}^{2+} + 2 \text{NO}_3^- \rightarrow \text{Ba}(\text{NO}_3)_2$
- (d) $\text{CO}_3^{2-} + 2 \text{H}^+ \rightarrow \text{H}_2\text{O} + \text{CO}_2$

23. Which of the following **best** describes 10 mol L⁻¹ ammonia?

- (a) A dilute solution of a weak base.
- (b) A concentrated solution of a weak base.
- (c) A dilute solution of a strong base.
- (d) A concentrated solution of a strong base.

24. For some titrations, phenolphthalein is a suitable indicator while methyl orange is unsuitable. For which one of the following is this the case?
- (a) Acetic acid (ethanoic acid) and ammonia solutions.
 - (b) Acetic acid and potassium hydroxide solutions.
 - (c) Nitric acid and ammonia solutions.
 - (d) Nitric acid and potassium hydroxide solutions.
25. Which one of the following describes the concentration of hydrogen ion in 1.00 mol L⁻¹ sulfuric acid?
- (a) Less than 1.00 mol L⁻¹
 - (b) Exactly 1.00 mol L⁻¹
 - (c) Between 1.00 and 2.00 mol L⁻¹
 - (d) Exactly 2.00 mol L⁻¹
26. Which expression gives the equilibrium constant, K, for the following reaction **in the gas phase**?



- (a) $K = \frac{[\text{H}_2\text{O}]^2}{[\text{H}_2]^2[\text{O}_2]}$
 - (b) $K = \frac{1}{[\text{H}_2]^2[\text{O}_2]}$
 - (c) $K = [\text{H}_2]^2[\text{O}_2]$
 - (d) $K = \frac{[2\text{H}_2\text{O}]}{[2\text{H}_2][\text{O}_2]}$
27. Which of the following is non-polar but consists of molecules in which there are polar covalent bonds?
- (a) Tetrachloromethane, CCl₄
 - (b) Nitrogen, N₂
 - (c) Water, H₂O
 - (d) Ammonia, NH₃
28. Which of the following compounds is the strongest electrolyte in aqueous solution?
- (a) Sodium ethanoate (acetate).
 - (b) Ammonia.
 - (c) Iodine.
 - (d) Ethanol.

29. Which of the following are Brønsted-Lowry acid-base reactions?

- I $\text{Mg} + 2 \text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2$
- II $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$
- III $3 \text{Cu} + 8 \text{H}^+ + 2 \text{NO}_3^- \rightarrow 3 \text{Cu}^{2+} + 2 \text{NO} + 4 \text{H}_2\text{O}$
- IV $\text{NH}_2^- + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{OH}^-$

- (a) I, II and III only
- (b) I and III only
- (c) II, III and IV only
- (d) II and IV only

30. In which of the following substances is metallic bonding significant at 100°C?

- I solid brass
- II solid iron(II) chloride
- III molten sodium
- IV solid sodium chloride

- (a) I only
- (b) I and III only
- (c) II only
- (d) II and IV only

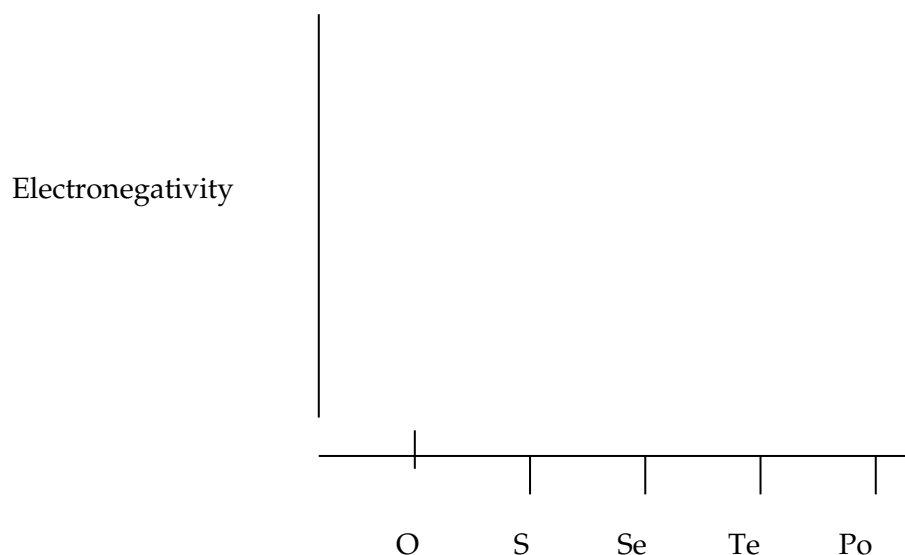
END OF PART 1

PART 2

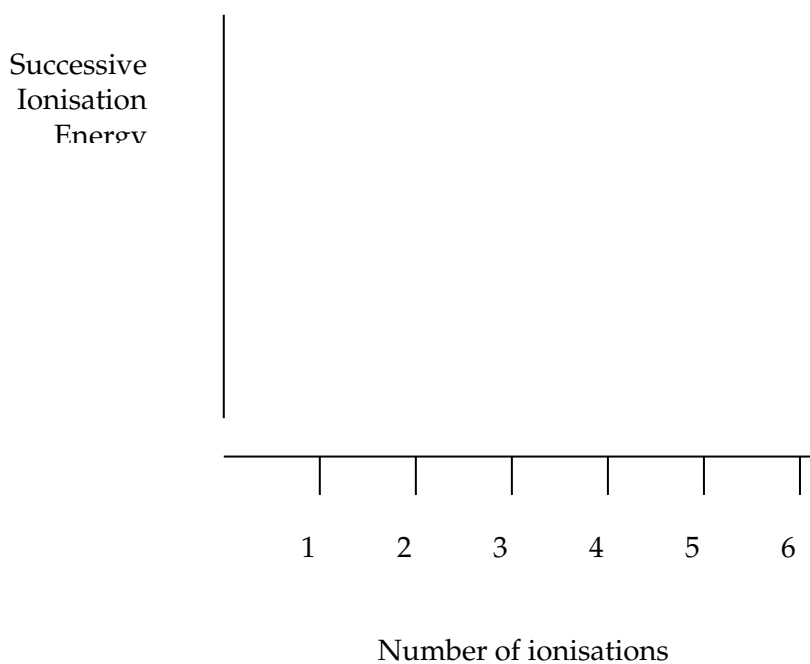
Answer **ALL** questions in Part 2 in the spaces provided. This part carries 35 marks.

1. Using the axes provided, draw sketch graphs of the following. You are not required to place any numbers on the scales.

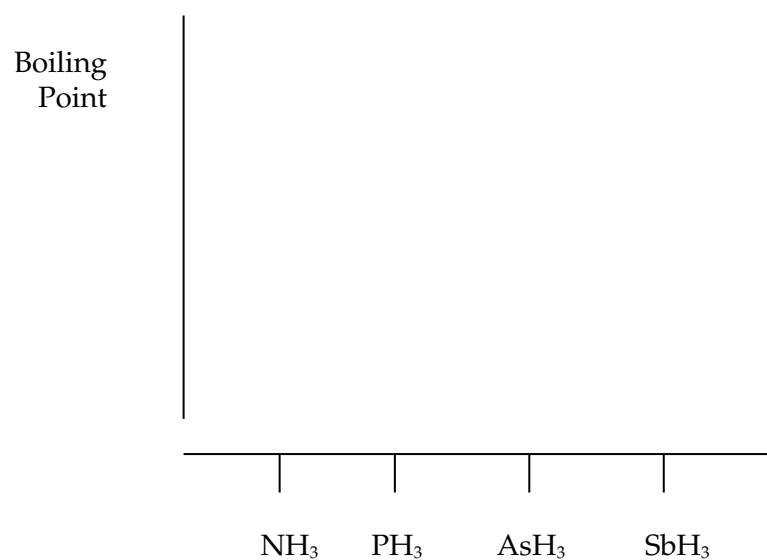
- (a) The electronegativities of the elements of group VI.



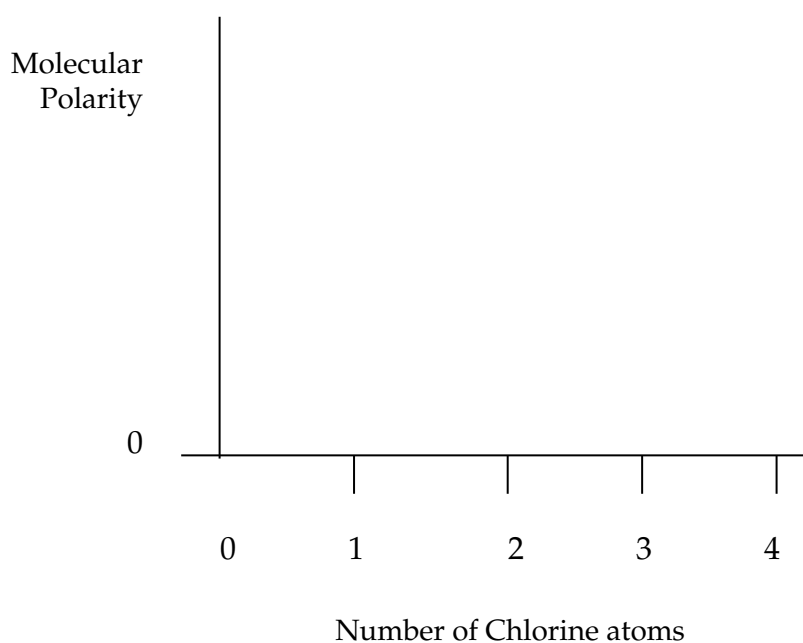
- (b) The first six successive ionisation energies of calcium.



- (c) The boiling points of the hydrides of group V elements.



- (d) the molecular polarity of chloro derivatives of methane as a function of the number of chlorine atoms in a molecule.



(6 marks)

2. Write the equation for the industrial synthesis of ammonia.

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This reaction takes place exceedingly slowly at room temperature and pressure. List three ways in which chemists control reaction conditions to **speed up** the process.

i
ii
iii

(4 marks)

3. Calculate the pH of $0.0250 \text{ mol L}^{-1}$ rubidium hydroxide, RbOH.

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(3 marks)

4. Explain the difference between the following terms.

(a) The “end point” and the “equivalence point” of an acid/base titration.

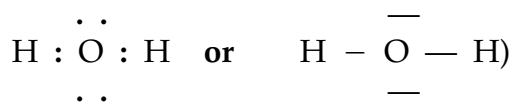
(1 mark)

(b) “Dilute acids” and “weak acids”.

(1 mark)

5. For each molecule listed in the table below

(i) draw the structural formula,
representing all valence shell electron pairs either as : or as -
(for example, water



(ii) indicate the shape of each molecule by either a sketch or a name.

Molecule	Structural formula (showing all valence shell electrons)	Shape (sketch or name)
carbon dioxide		
hydrogen sulfide		
nitrate ion		

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(6 marks)

6. Examine the Periodic Table shown below :

																(g)
														(f)		
												(d)		(e)		
						(c)										(h)
(a)																
	(b)															

- (i) What type of bonding would you expect to find in element (c) in the solid state?

Answer _____

(1 mark)

- (ii) What type of bonding would you expect to find in the compound formed between elements (a) and (f)?

Answer _____

(1 mark)

- (iii) What type of bonding would you expect to find in a compound of element (f) with hydrogen?

Answer _____

(1 mark)

- (iv) How many atoms of (f) would combine with one atom of (d)?

Answer _____

(1 mark)

- (v) Which of the elements labelled (a) to (h) would be likely to have a strongly basic hydroxide and form ions with a charge of +2?

Answer _____

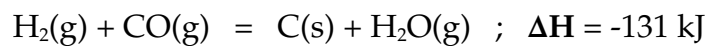
(1 mark)

- (vi) What would be the ground state electronic configuration of an atom of element (f)? (The notation you use should show principal energy levels and sub-shells.)

Answer _____

(1 mark)

7. Consider the following system at equilibrium in a closed vessel :



- (a) The equilibrium is disturbed by increasing the temperature. After a new equilibrium is established, is the amount of CO more, less or the same as before?

Answer _____
(1 mark)

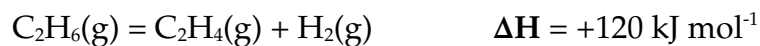
- (b) If the original equilibrium was disturbed by decreasing the volume of the reaction vessel, keeping the temperature constant, would the amount of CO be more, less or the same as before? Explain.

(1 mark)

- (c) If solid carbon were added to the system at equilibrium, would the amount of CO be more, less or the same as before? Explain.

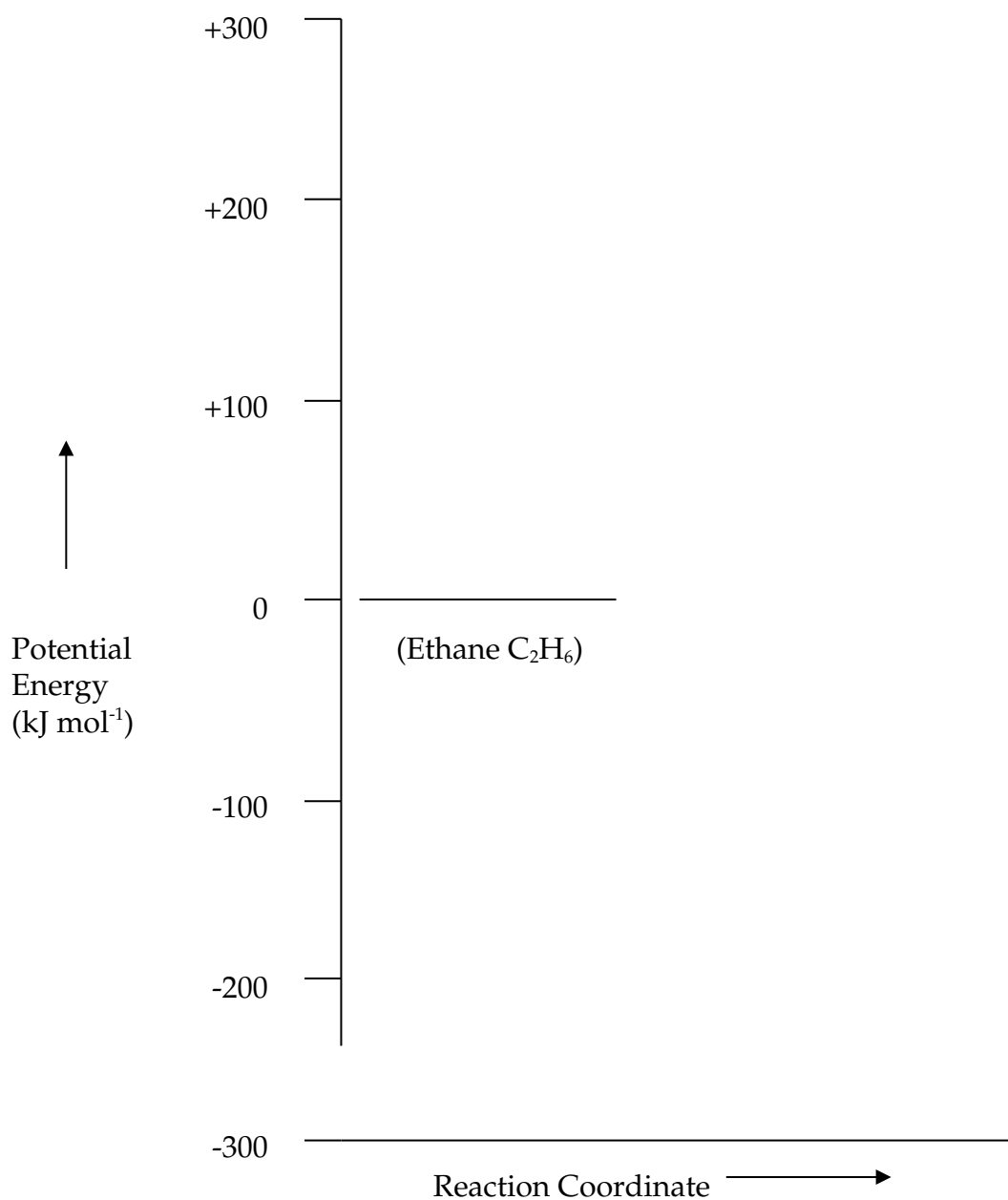
(1 mark)

8. Ethene may be produced from ethane by heating it in the presence of a catalyst. The reaction can be represented by the equation :



On the axes below

- (i) draw a potential energy diagram for the uncatalysed reaction if the activation energy is 180 kJ mol^{-1} .
- (ii) using a dotted line, draw a possible potential energy diagram for the same reaction in the presence of a catalyst.



(2 marks)

9. The following six substances have their boiling points listed in the table below.

Acetic acid (ethanoic acid), CH_3COOH

Ethanol, $\text{CH}_3\text{CH}_2\text{OH}$

Hydrogen chloride, HCl

Hydrogen fluoride, HF

Methane, CH_4

Water, H_2O

Consider the intermolecular forces between the molecules and so estimate the relative boiling points of the substances. Hence complete the table by writing the formulae of the substances in the appropriate places.

Formula	Boiling point ($^{\circ}\text{C}$)
	-162
	-85
	19
	78
	100
	118

(3 marks)

END OF PART 2

PART 3

Answer **ALL** questions in Part 3. The calculations are to be set out in detail in this Question/Answer Booklet. Marks will be allocated for correct equations and clear setting out of your answer, even if you cannot complete the problem. This part carries 25 marks.

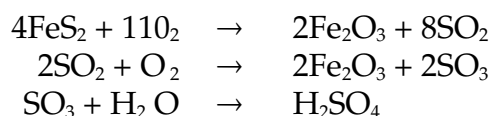
1. 2.440 g of a mixture of anhydrous sodium chloride and anhydrous sodium hydrogencarbonate required 18.5 mL of 0.705 mol L⁻¹ sulfuric acid for complete neutralisation. Calculate the percentage by mass of sodium chloride in the mixture.

(5 marks)

[illegible]

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2. The preparation of sulfuric acid from iron pyrites (FeS_2) can be represented by the following series of reactions.



What mass of iron pyrites would be needed to produce 125 kg of 90.0% sulfuric acid if the contact process converts 95.0% of the sulfur dioxide and the other reactions achieve 100% conversion?

(5 marks)

[illegible]

[illegible]

3. Three solutions, A, B and C have the following composition :

Solution A 50.0 mL of 0.500 mol L⁻¹ sulfuric acid was diluted with distilled water and the resulting solution made up to 250.0 mL.

Solution B 560.0 mL of hydrogen chloride gas at S.T.P. was dissolved in distilled water and the resulting solution made up to 500 mL.

Solution C 100.0 mL contains 3.20 g of sodium hydroxide.

- Calculate the molar concentration of each solution.
- 20.0 mL of solution A and 50.0 mL of solution B are mixed. Calculate the concentration of hydrogen ions in the mixture.

- (b) 20.0 mL of solution A and 50.0 mL of solution B are mixed. Calculate the concentration of hydrogen ions in the mixture.

(6 marks)

[illegible]

[illegible]

4. An analyst has a pure substance 'A' which is a weak acid and she decides to determine its molecular weight by titration.

She dissolves 1.3867 g of 'A' in water and makes the solution up to 250.0 mL in a volumetric flask. She then titrates 20.00 mL portions of the solution of 'A' with 0.09826 mol L⁻¹ sodium hydroxide *from the burette* using phenolphthalein as indicator, and records the following titration figures.

Final reading (mL)	20	19.5	18.32	17.77	18.87	
Initial reading (mL)	0.11	1.32	0.67	0.08	1.20	

- (a) Calculate the appropriate value for the volume of sodium hydroxide solution required for titration.
(1 mark)
- (b) Assume that 'A' is a monoprotic acid and calculate the number of moles of 'A' in the 1.3867 g of 'A'.
(5 marks)
- (c) Use this value to calculate the molecular weight of 'A'.
(2 marks).
- (d) Assume that 'A' is a diprotic acid and calculate its molecular weight.
(1 mark)

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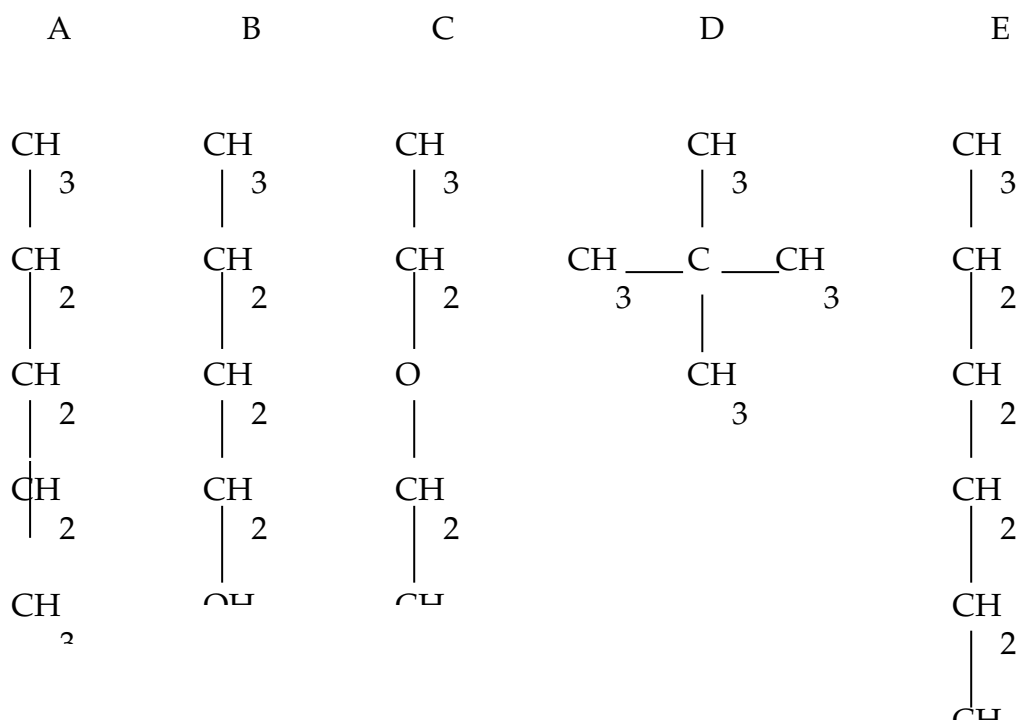
[illegible]

END OF PART 3

PART 4

Answer **ONE** of the following extended answer questions. Where applicable, use equations, diagrams and illustrative examples of the chemistry you are describing. Marks are awarded principally for the relevant chemical content of your answer, but some marks can also be gained for clarity in arranging a reasonable amount of material in a coherent form. Your answer should be presented in about $1\frac{1}{2}$ — 2 pages. This part carries 10 marks.

1. One of the commonest materials you will have come across in your laboratory work is water. Describe the chemistry of water. Your answer should include references to the molecular structure of liquid water, ionisation, hydrolysis, K_w and pH; and water as a solvent, an acid, a base and a weak electrolyte.
2. *Bonds range from pure covalent through polar covalent to ionic.*
Discuss this statement using binary compounds (compounds of two elements) as examples. In your discussion
 - * clearly state how and why the progression from pure covalent to ionic bonding occurs, and
 - * explain how bonding type influences the properties of the compounds.
3. Arrange the following in the order you should expect for their boiling points, putting the one with the highest boiling point first. Using substances A to E as examples, discuss the effect of intermolecular forces on boiling points. (In your answer there is no need to use the names of the substances; refer to them by the labels, A, B, C, D and E.)



END OF QUESTIONS
