

IONA PRESENTATION COLLEGE



Year 12 Chemistry

Semester Two Examination, 2002

Student Name : _____

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work:	Ten minutes
Working time for paper:	Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question Paper/Answer Booklet
Separate Multiple Choice Answer Sheet
Chemistry/Data Sheet (inside front cover of this Question/Answer booklet)

TO BE PROVIDED BY THE CANDIDATE

<i>Standard Items:</i>	Pens, pencils, eraser or correction fluid, ruler
<i>Special Items:</i>	Calculators satisfying the conditions set by the Curriculum Council and a 2B, B or HB pencil for the separate Multiple Choice Answer Sheet.

IMPORTANT NOTE TO CANDIDATES

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.

STRUCTURE OF THIS PAPER

Part	Format	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (Approx) /Minutes
1.	Multiple choice	30	ALL	60 (30%)	55
2.	Short answers	11	ALL	70 (35%)	60
3.	Calculations	5	ALL	50 (25%)	45
4.	Extended answers	2	1	20 (10%)	20

Total marks for paper = 200 (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

Answer **ALL** questions, using a pen, on the separate Multiple Choice Answer Sheet.

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.

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 – MULTIPLE CHOICE

(60 marks = 30% of the total)

Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet provided.

1. In which one of the following pairs do both species have the same electron configuration?
 - (a) Na and Mg
 - (b) Na^+ and K^+
 - (c) Na^+ and Ar
 - (d) Na^+ and Ne

2. An atom has the first five successive ionization energies
1.1 2.4 4.6 6.2 37.8 MJ mol^{-1}
Which of the following elements is it?
 - (a) Aluminium
 - (b) Argon
 - (c) Calcium
 - (d) Carbon

3. Substance Z is a white crystalline solid that melts at 81°C . Z does not conduct electricity in either the solid or the liquid state.
Which of the following is most likely to be the structure of Z?
 - (a) Ionic
 - (b) Covalent network
 - (c) Non-metallic network
 - (d) Covalent molecular

4. Which of the following statements best describes why metals conduct electricity?
 - (a) A metal atom has only one electron in its valence shell and this is easily removed.
 - (b) Metal atoms are not tightly bonded one to another.
 - (c) The nuclei of metal atoms are arranged in a three dimensional network.
 - (d) The valence electrons in metals are delocalised.

5. Which one of the following substances has linear molecules?
 - (a) NH_3
 - (b) CO_2
 - (c) SO_2
 - (d) CCl_4

6. In which one of the following compounds are **both** ionic **and** covalent bonding present?
 - (a) Ammonium chloride
 - (b) Hydrogen chloride
 - (c) Potassium chloride
 - (d) Trichloromethane (chloroform)

SEE NEXT PAGE

7. Consider the intermolecular forces in the following compounds, and so predict which compound has the lowest boiling point (at 1.00 atm).
- (a) PH_3 [phosphine].
 - (b) AsH_3 [arsine].
 - (c) SbH_3 [stibine].
 - (d) BiH_3 [bismuthine].
8. Species 'X' has the valence electron configuration of s^2 , and 'Z' has the valence electron configuration of s^2p^5 . Which of the following is the most likely formula of a compound formed between 'X' and 'Z'?
- (a) XZ
 - (b) XZ_2
 - (c) X_2Z_5
 - (d) X_2Z_7
9. Which of the following statements is true about the sequence of oxides of period three elements?
- Na_2O Al_2O_3 SO_3
- (a) The boiling points increase.
 - (b) The extent of reaction with water increases.
 - (c) The relative formula masses (molecular weights) increase.
 - (d) The oxides become increasingly acidic.
10. Which of the following **CANNOT** be a typical property of vanadium (atomic number 23)?
- (a) Vanadium might form more than one oxide.
 - (b) The element vanadium might be a strong oxidizing agent.
 - (c) Vanadium might form complex ions.
 - (d) Vanadium might form blue ions.
11. Which one of the following contains no electrons in a d sublevel when in its ground state?
- (a) I
 - (b) Fe
 - (c) K
 - (d) Se
12. Which one of the following molecules is non-polar; that is, the molecule has no overall dipole moment?
- (a) CHCl_3
 - (b) H_2O
 - (c) CO_2
 - (d) SO_2

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13. 25.00 mL of 1.50 mol L^{-1} hydrochloric acid is made up to 100.00 mL with distilled water. What is the concentration of the solution produced?
- (a) 0.375 mol L^{-1}
(b) 0.500 mol L^{-1}
(c) 1.00 mol L^{-1}
(d) 4.50 mol L^{-1}

14. A compound is one of the following:

iron (II) sulfate
iron (III) chloride
cobalt iodide
copper (II) carbonate
nickel nitrate

The pale green crystals of the compound dissolve readily in water to give an almost colourless solution.

When some of this solution is treated with sodium hydroxide solution a pale green precipitate forms which turns brown over time.

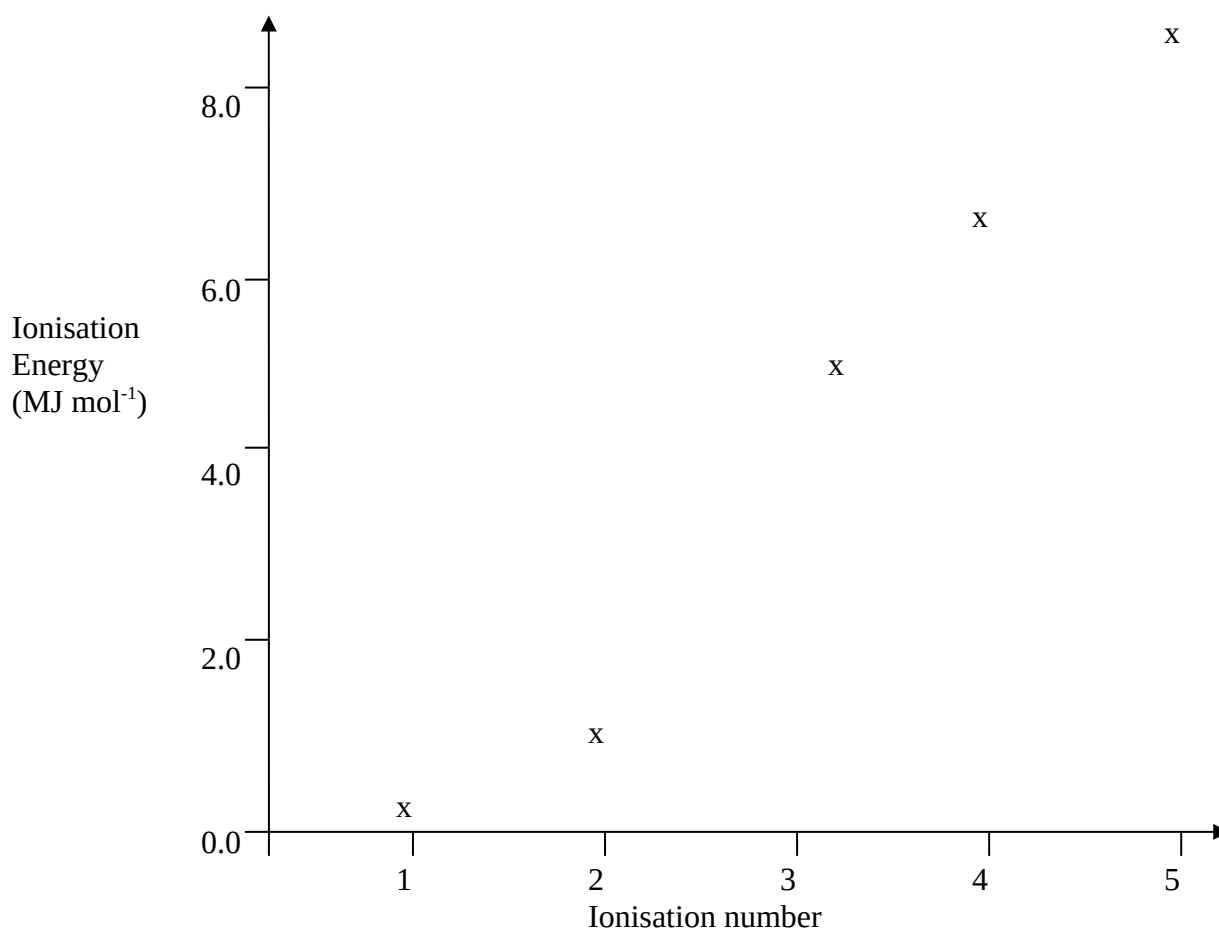
A fresh sample of the solution decolourises a solution containing potassium permanganate and sulfuric acid.

What is the compound?

- (a) FeSO_4
(b) FeCl_3
(c) CoI_2
(d) $\text{Ni}(\text{NO}_3)_2$
15. A chemist wishes to make a fertilizer solution containing ions that will act as a source of nitrogen, phosphorus and potassium. Which one of the following mixtures of solids will completely dissolve to give such a solution?
- (a) K_3PO_4 $\text{Ca}(\text{NO}_3)_2$ KCl
(b) K_2CO_3 K_3PO_4 $\text{Ba}(\text{NO}_3)_2$
(c) NH_4NO_3 Na_3PO_4 KCl
(d) NH_4Cl K_3PO_4 CaCl_2

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16. An element has the first five successive ionization energies as shown on the graph below.



Which one of the following is it?

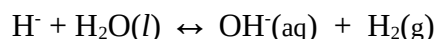
- (a) aluminium
 - (b) calcium
 - (c) carbon
 - (d) neon
17. Which one of the following best describes, for the elements across the third row of the periodic table: the trends in the first ionization energy and acidity of the oxides?
- (a) Going from left to right: the first ionization energy decreases; and the acidity of the oxides decreases while their basicity increases.
 - (b) Going from left to right: the first ionization energy decreases; and the acidity of the oxides increases while their basicity decreases.
 - (c) Going from left to right: the first ionization energy increases; and the acidity of the oxides decreases while their basicity increases.
 - (d) Going from left to right: the first ionization energy increases; and the acidity of the oxides increases while their basicity decreases.

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- 18 Which one of the following is the formula of the complex ion formed between one silver ion and two cyanide ions?

(a) $[\text{Ag}(\text{CN})_2]^{2-}$.
(b) $[\text{Ag}(\text{CN})_2]^-$.
(c) $[\text{Ag}(\text{CN})_2]^+$.
(d) $[\text{Ag}(\text{CN})_2]^{2+}$.

19. Group I and II metal hydrides react with water according to the following equation:



In a particular experiment, 1.00g of each of the following metal hydrides is treated with an excess of water. Which metal hydride will produce the greatest volume of hydrogen?

- (a) NaH
(b) KH
(c) MgH_2
(d) CaH_2
20. Since strong bases such as NaOH and KOH absorb moisture from the air, they cannot be used in volumetric analysis as primary standards. As standard hydroxide solution can however be prepared by dissolving a known quantity of mercury (II) oxide in excess KBr solution, when the following reaction occurs



When 0.1000 mol of HgO is dissolved in a solution of 1.5 mol of KBr in 300mL of water and the solution made up to 1.0000 L, what is the hydroxide ion concentration in the standard solution?

- (a) $0.2000 \text{ mol L}^{-1}$
(b) $0.3750 \text{ mol L}^{-1}$
(c) $0.4750 \text{ mol L}^{-1}$
(d) 1.600 mol L^{-1}
21. In a chemical reaction at constant temperature, the addition of a catalyst
- (a) increases the concentration of products at equilibrium.
(b) increases the fraction of molecules with more than a given energy.
(c) decreases the time required for equilibrium to be reached.
(d) lowers the amount of energy released in the overall reaction.
22. Consider the following substances: C (graphite), C_3H_8 , $\text{CH}_3\text{CHC}/\text{CH}_3$, $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$. Which of the following correctly represents these substances in order of increasing boiling point?
- (a) $\text{C}_3\text{H}_8 < \text{CH}_3\text{CHC}/\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} < \text{C}$
(b) $\text{C} < \text{C}_3\text{H}_8 < \text{CH}_3\text{CH}/\text{CH}_2\text{OH} < \text{CH}_3\text{CHC}/\text{CH}_3$.
(c) $\text{CH}_3\text{CHC}/\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} < \text{C}_3\text{H}_8 < \text{C}$
(d) $\text{C}_3\text{H}_8 < \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} < \text{CH}_3\text{CHC}/\text{CH}_3 < \text{C}$

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23. Which one of the following properties generally decreases when going across a row of the Periodic Table from Group I to Group VII?
- (a) Oxidising ability.
 - (b) The acidity of the oxides.
 - (c) The number of electrons in the valence shell.
 - (d) The tendency of the element to form positive ions.
24. What is the maximum number of **unpaired** electrons possible in 3d orbitals?
- (a) 3
 - (b) 5
 - (c) 6
 - (d) 10
25. In which region of the Periodic Table would you find elements whose chlorides are covalent at room temperature?
- (a) The top left hand region
 - (b) The bottom left hand region
 - (c) The top right hand region
 - (d) The bottom right hand region

INFORMATION FOR QUESTIONS 26 AND 27

The following two questions are about a step in the production of nickel at the Kwinana Nickel Refinery. The ore is originally treated with ammonia and oxygen, converting the nickel into tetraamminenickel ion. In the next step, considered here, this complex ion is treated with hydrogen gas and converted to nickel metal. The forward reaction is represented by the following equation



26. Which of the following sets of conditions will bring about the **highest yield** of nickel at equilibrium?
- (a) High partial pressure of hydrogen and low partial pressure of ammonia
 - (b) High partial pressure of hydrogen and high partial pressure of ammonia
 - (c) Low partial pressure of hydrogen and low partial pressure of ammonia
 - (d) Low partial pressure of hydrogen and high partial pressure of ammonia
27. Which of the following conditions will bring about the **fastest rate** of formation of nickel?
- (a) High partial pressure of hydrogen
 - (b) Low partial pressure of hydrogen
 - (c) High partial pressure of ammonia
 - (d) Low partial pressure of ammonia

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28. Consider the following reaction at equilibrium.



Which one of the following changes will increase the concentration of $\text{NO}_2(\text{g})$ in the mixture when equilibrium is re-established?

- (a) decreasing the concentration of NO at constant temperature and pressure
 - (b) decreasing the concentration of O_2 at constant temperature and pressure
 - (c) decreasing the pressure
 - (d) decreasing the temperature
29. Consider the reversible reaction
- $$\underset{\text{yellow}}{2\text{CrO}_4^{2-}(\text{aq})} + 2\text{H}^+(\text{aq}) \rightleftharpoons \underset{\text{orange}}{\text{Cr}_2\text{O}_7^{2-}(\text{aq})} + \text{H}_2\text{O}(\text{l}) \quad \Delta H = 21 \text{ kJ mol}^{-1}$$
- An equilibrium mixture is prepared, yellow-orange in colour, containing both sodium chromate and sodium dichromate in solution. Which one of the following statements is **false**?
- (a) when dilute hydrochloric acid is added, the mixture becomes both less yellow and more orange.
 - (b) When a few crystals of sodium chromate are added and dissolved, the mixture becomes both more orange and more yellow.
 - (c) When a little barium chloride solution is added so that insoluble barium chromate precipitates, the solution becomes both less orange and less yellow.
 - (d) When the temperature is increased, the value of the equilibrium constant does not change.
30. Which one of the following processes is exothermic?
- (a) $\text{I}_2(\text{g}) \rightleftharpoons 2\text{I}(\text{g})$
 - (b) $\text{I}_2(\text{s}) \rightleftharpoons \text{I}_2(\text{g})$
 - (c) $\text{Na}(\text{g}) \rightleftharpoons \text{Na}^+(\text{g}) + \text{e}^-$
 - (d) $\text{Na}^+(\text{g}) + \text{I}^-(\text{g}) \rightleftharpoons \text{NaI}(\text{s})$

END OF PART 1

PART 2 (70 marks = 35% of paper)

Answer ALL questions in Part 2 in the spaces provided below.

1. Write equations for any reactions that occur in the following procedures. If no reaction occurs write 'no reaction'.

In each case describe **in full** what you would observe, including any

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

- (a) Copper (II) nitrate solution is added to sodium carbonate solution.

Equation _____

Observation _____

[3 marks]

- (b) Zinc oxide is warmed with dilute sulfuric acid

Equation _____

Observation _____

[3 marks]

- (c) Dilute hydrochloric acid is added to solid silver.

Equation _____

Observation _____

[3 marks]

- (d) Freshly precipitated copper (II) hydroxide is shaken with an excess of ammonia solution.

Equation _____

Observation _____

[3 marks]

SEE NEXT PAGE

2. For each species listed in the table below
- (a) draw the structural formula,
including all valence shell electron pairs and representing each either as : or as –
[for example, water H O:H or H – O – H or H – H and so on]
- (b) indicate the shape of each species by either sketch or a name
- (c) indicate the polarity of each species. Write ‘non-polar’ or ‘polar’.

In each of the three species, sulfur is the central atom.

Species	Structural formula (showing all valence shell electrons)	Shape (sketch or name)	Polarity (‘non-polar’ or ‘polar’)
Sulfur dioxide, SO_2			
Carbon dioxide CO_2			
Sulfite ion SO_3^{2-}			

[12 marks]

3. Consider the equilibrium



An equilibrium mixture is set up by dissolving cobalt chloride in water to make a concentrated solution, and then adding concentrated hydrochloric acid until the mixture is purple. The solution is divided into three parts, and each part is treated as described in the table. Explain the observations. [A statement such as 'nc', ' \rightarrow ', or ' \leftarrow ' is not sufficient as an explanation.]

Experiment and Observation	Explanation
A little concentrated hydrochloric acid is added and the mixture turns more blue and less red.	
A little silver nitrate solution is added. There is a precipitate and the mixture turns more red and less blue.	
The solution is warmed and the mixture turns more blue and less red.	

[6 marks]

4. Write the equilibrium constant expression for each of the following:

Equation	$2\text{H}_2\text{O}(\text{l}) + 4\text{Au}(\text{s}) + \text{O}_2(\text{g}) + 8\text{CN}^-(\text{aq}) \rightleftharpoons 4\text{Au}(\text{CN})_2^-(\text{aq}) + 4\text{OH}^-(\text{aq})$
Equilibrium constant expression	

Equation	$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$
Equilibrium constant expression	

[4 marks]

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5. A small piece of rubidium metal (Rb) is added to water.

(a) Write the equation for the reaction

[2 marks]

(b) Would you expect this reaction to be slow or rapid? Explain

[3 marks]

6. Element X has the outer electron structure s^2p^3 .

(a) Write the formula for the hydride of X. _____

(b) What monoatomic ion would X be likely to form? _____

[4 marks]

7. The electron configuration of the lithium atom is $1s^2 2s^1$. using the same notation, give the electron configuration of

(a) A magnesium atom _____

(b) A sulfide ion _____

[4 marks]

SEE NEXT PAGE

8. A series of four HCl solutions with different concentrations was prepared, and tested with the indicator erythrosine. The results are set out below.

PH	Erythrosin colour
1.0	Yellow
2.0	Yellow
3.0	Orange
4.0	red

On the basis of the above experiment, what can be concluded about the pH of two unknown solutions which when tested with erythrosine gave the following results?

Unknown solution	Erythrosin colour	pH
A	orange	
B	red	

[4 marks]

9. Using the information in the table, identify the substances A, B, C, and D from the following list:

Aluminium oxide
Candle wax
Cobalt nitrate
Copper
Gold
Silicon dioxide
Sodium chloride
Sucrose (cane sugar)
Sulfur

Sub- stance	Electrical conductivity			Solubility in water	Colour of solid	Name of substance
	Solid	Liquid	Water solution			
A	nil	conducts	conducts	Soluble	White	
B	nil	nil	nil	Soluble	White	
C	conducts	conducts	–	Insoluble	Pink	
D	nil	conducts	–	insoluble	white	

[8 marks]

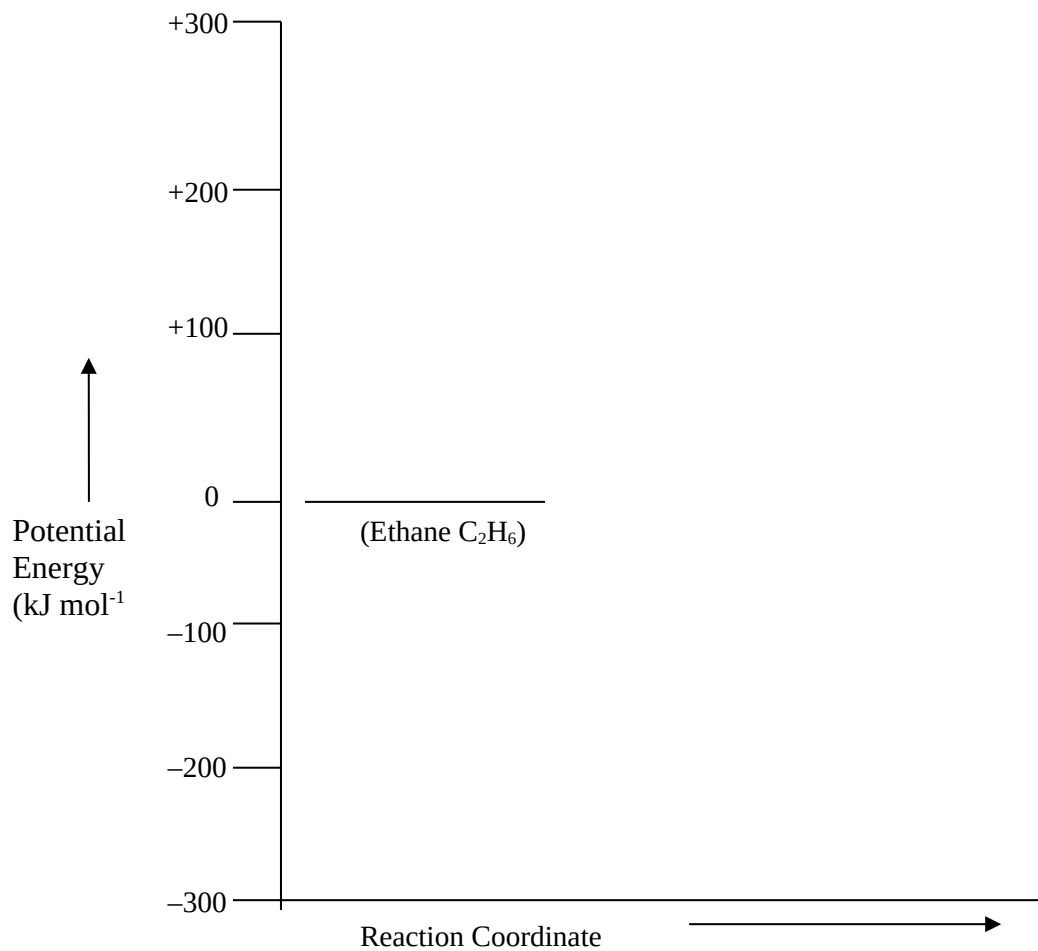
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10. Ethene may be produced from ethane by heating it in the presence of a catalyst. The reaction can be represented by the equation :



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.



[5 marks]

PLEASE SEE NEXT PAGE

- 11 For each of the following pairs of substances predict which one of the pair will have the highest boiling point. Give reasons for your choice in each case.

Pairs of substances	Predictions – which substance has the highest boiling point	Reasons
Propane and Ethanol		
Hydrogen sulfide and water		
Ammonia and Phosphorous trihydride		

[6 marks]

END OF PART 2

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, even if you cannot complete the problem. When questions are divided into sections, working for each section must be clearly distinguished using a, b, etc. Final numerical answers MUST be corrected to three (3) significant figures where appropriate and units MUST be provided where applicable. Information, which may be necessary for solving the problems, is located on the Separate Chemical Data Sheet. Failure to show reasoning clearly will result in loss of marks. This part carries 50 marks (25% of the total).

1. A sample of industrial waste water is analysed and found to contain magnesium sulfate as the only significant impurity.

A 5.00 L sample of this waste water is evaporated to about 200 mL and sufficient barium nitrate solution is added to precipitate all the sulfate ion. The precipitate is washed with distilled water, filtered and dried. The mass of the precipitate is found to be 1.70g.

- (a) Determine the concentration in mg L^{-1} of magnesium sulfate in the waste water. [5 marks]

- (b) What mass of washing soda, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$, would need to be added to 100.00 L of the waste water to precipitate all the magnesium ion? [5 marks]

[illegible]

[illegible]

- | | | | | | |
|----------------------|------|------|-------|-------|-------|
| Final reading (mL) | 10 | 17 | 23.32 | 29.50 | 35.70 |
| Initial reading (mL) | 0.07 | 9.96 | 17.10 | 23.32 | 29.50 |
| | | | | | |

- [2 marks]

- [8 marks]

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Step 1 : The concentration of a sodium hydroxide solution was determined by titration against 0.105 mol L⁻¹ hydrochloric acid, using phenolphthalein as the indicator. 20.00 mL of hydrochloric acid required 22.35 mL of sodium hydroxide solution to reach the end point.

Step 3 : The **diluted** battery acid was titrated with the sodium hydroxide solution which was standardized in Step 1. 19.15 mL of the standard sodium hydroxide solution was required to react completely with 20.00 mL of the **diluted** battery acid using phenolphthalein as the indicator.

- [10 marks]

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[illegible]

- [10 marks]

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[illegible]

- $$5 \text{ SF}_4(\text{g}) + 2 \text{ I}_2\text{O}_5(\text{s}) \rightarrow 4 \text{ IF}_5(\text{l}) + 5 \text{ SO}_2(\text{g})$$

(a) What volume of sulfur dioxide is produced at 760°C and 120 kPa? [5 marks]

- (b) What mass of each of the substances (reactants and products) is present at the completion of the reaction? [5 marks]

[illegible]

[illegible]

PART 4 (20 marks = 10% of paper)

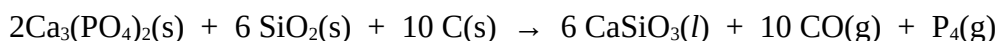
Answer ONE of the following two extended answer questions. Where applicable use equations, diagrams and illustrate examples of the chemistry you are describing.

Marks are awarded for the relevant chemical content of your answer, and also for coherence and clarity of expression. Your answer should be presented in about 1 ½ – 2 pages. Write your essay on the lined sheets at the end of these questions.

1. Phosphoric acid, H_3PO_4 , is one of the most widely produced industrial chemicals in the world. Pure phosphoric acid is a colourless solid with a melting point of 42°C .

Phosphoric acid has a vast range of uses, the major one being in the production of fertilizers, since phosphorus is essential for plant growth. Phosphoric acid is also used in the manufacture of detergents. Phosphoric acid is added to soft drinks to give a 'tangy' flavour and an appropriate acid pH. The anhydride of H_3PO_4 (which is P_4O_{10}) has such a strong affinity for water that it is used as a drying agent.

In one method for producing phosphoric acid, $\text{Ca}_3(\text{PO}_4)_2$ from phosphate rock is heated in an electric furnace with SiO_2 and C(graphite). This produces P_4 as a hot vapour according to the following equation.



$$\Delta H = 3060 \text{ kJ per mole of } \text{P}_4$$

The reaction mixture can reach a temperature of about 20000°C . In some modern plants the heat generated is used to power steam turbines.

The P_4 is converted into P_4O_{10} by the combustion of phosphorus vapour, as it is produced by the furnace ($\Delta H = 3053 \text{ kJ per mole of } \text{P}_4$). [This reaction can occur spontaneously at room temperature.]

The H_3PO_4 is formed by passing the P_4O_{10} through a spray of water in a tower ($\Delta H = 377 \text{ kJ per mole of } \text{P}_4\text{O}_{10}$).

Compare and contrast this information about phosphoric acid with the manufacture and uses of sulfuric acid.

OR

2. Discuss the solubility or miscibility of sodium chloride, tetrachloromethane (carbon tetrachloride), ethanol and graphite in

(a) Water

(b) petrol (octane)

and propose simple explanations in terms of interactions between solute and solvent particles to account for the observed differences.

END OF QUESTIONS

[illegible]

[illegible]

[illegible]

[illegible]