Kolbe Catholic College

YEAR 12 CHEMISTRY EXAMINATION

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

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser or correction fluid, ruler

Special Items: A 2B, B or HB pencil for the separate Multiple Choice Answer Sheet and calculators satisfying the conditions set by the Curriculum Council.

IMPORTANT NOTE TO CANDIDATES

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.

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	60 (30%)	55
2	Short answers	12	ALL	70 (35%)	60
3	Calculations	6	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 2B, B or HB pencil, on the separate Multiple Choice Answer Sheet. Do **NOT** use a ball point 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 ball point or ink pen. **Do not** answer in pencil. Write your answers in **this** Question/Answer Booklet.

At the end of the examination, check that your Name has been placed in the spaces provided on the front cover of this 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 Ag^+ (aq)], **molecules** [for example NH_3(g), NH_3(aq), CH_3COOH (l), CH_3COOH (aq)] or **solids** [for example $BaSO_4$(s), Cu(s), Na_2CO_3(s)].

PART 1 (60 marks = 30% of paper)

Answer ALL questions in Part 1 on the Separate Multiple Choice Answer Sheet provided, use a 2B, B or HB pencil. Each question in this part is worth 2 marks.

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1. Calculate the mass of solute dissolved in 250 mL of 0.2 mol L^{-1} sodium hydroxide solution.

   a) 0.1 g b) 0.2g
   c) 2.0 g d) 8.0g

2. 100 mL of 2.00 mol L^{-1} sodium hydroxide is mixed with 50.0 mL of 2.50 mol L^{-1} sodium hydroxide, then 50.0 mL of distilled water is added to the solution. What is the concentration of the final sodium hydroxide solution produced?

   a) 1.62 mol L^{-1} b) 2.17 mol L^{-1}
   c) 2.25 mol L^{-1} d) 2.40 mol L^{-1}

3. Calculate the concentration of chloride ions in 20 mL of a 0.5 mol L^{-1} solution of aluminium chloride.

   a) 0.5 mol L^{-1} b) 1.0 mol L^{-1}
   c) 1.5 mol L^{-1} d) 2.0 mol L^{-1}

4. Consider the following two solutions:

   Solution 1 consists of 1 mol L^{-1} iron (III) sulfate and Solution 2 consists of 1 mol L^{-1} sodium sulfate.

   Which of the following statements is TRUE?

   a) The $[SO_4^{2-}]$ in Solution 1 is 1.5 times the $[SO_4^{2-}]$ in Solution 2.
   b) The $[Na^+]$ is Solution 2 is equal to the $[Fe^{3+}]$ in Solution 1.
   c) The $[Na^+]$ in Solution 2 is half the $[SO_4^{2-}]$ in Solution 1.
   d) The $[Fe^{3+}]$ in Solution 1 is equal to the $[SO_4^{2-}]$ in Solution 2.

5. Identify which ONE of the following pairs of *solutions* would produce a precipitate when mixed together.

   a) $Fe(NO_3)_3$ and K_3PO_4.
   b) NH_4NO_3 and Na_2CO_3.
   c) $Ca(NO_3)_2$ and NaCl.
   d) $MgCl_2$ and NaBr.

6. What colour is $Fe(OH)_2$?

   a) Green.
   b) Brown.
   c) White.
   d) Yellow.

7. Which one of the equations below is NOT balanced?

a) $2KClO_3 \Rightarrow 2KCl + 2O_2$
b) $Fe_2O_3(s) + 3CO(g) \Rightarrow 2Fe(l) + 3CO_2(g)$
c) $Zn(s) + 2HCl(aq) \Rightarrow ZnCl_2(aq) + H_2(g)$
d) $2HgO \Rightarrow 2Hg + O_2$

The next two questions refer to the equation below which shows the decomposition of zinc carbonate upon heating.

$$ZnCO_3(s) \xRightarrow{heat} ZnO(s) + CO_2(g)$$

8. If 2.5 g of zinc carbonate is heated, what mass of zinc oxide would be produced?

a) 0.02 g b) 0.8 g
c) 1.6 g d) 3.2 g

9. If the carbon dioxide produced in the above reaction was collected and conditions set to STP, what volume would the carbon dioxide gas occupy?

a) 88.0 mL b) 100.0 mL
c) 22.4 mL d) 448 mL

10. The equation for the reaction between hydrochloric acid and sodium thiosulfate can be represented as :

$$S_2O_3^{2-}(aq) + 2H^+(aq) \Rightarrow H_2O(l) + SO_2(g) + S(s)$$

Which one of the following would NOT increase the rate of this reaction?

a) Increasing the temperature of the reacting solutions.
b) Increasing the concentration of sodium thiosulfate.
c) Increasing the concentration of the hydrochloric acid used.
d) Increasing the air pressure around the reaction vessel.

11. The equilibrium expression, k, for the reaction:

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$, would be

a) $k = \dfrac{[N_2O_4]}{2[NO_2]}$
b) $k = \dfrac{2[NO_2]}{[N_2O_4]}$
c) $k = \dfrac{[N_2O_4]}{[NO_2]^2}$
d) $k = \dfrac{[NO_2]^2}{[N_2O_4]}$

12. What would happen to the value of k in the reaction described in question 11, if the pressure of the N_2O_4 is doubled?

    a) k would not be affected.
    b) k would be halved.
    c) k would be doubled.
    d) k would increase by a factor of 4.

13. Which of the following is used as a primary standard in acid-base titrations?

    a) Hydrochloric acid.
    b) Sodium carbonate.
    c) Sodium hydroxide.
    d) Sulfuric acid.

14. Which one of the following acids is diprotic?

    a) Nitric acid.
    b) Phosphoric acid.
    c) Ethanoic acid.
    d) Sulfuric acid.

15. If a solution has a pH of 10, then the hydroxide ion concentration of the solution is

    a) 10 mol L^{-1}
    b) 0.1 mol L^{-1}
    c) 0.04 mol L^{-1}
    d) 0.0001 mol L^{-1}

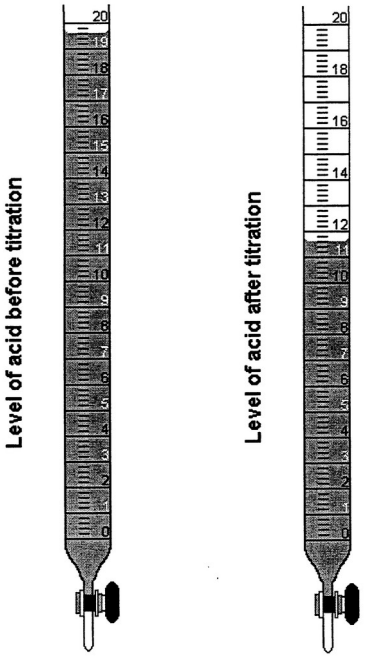
16. In volumetric analysis work, the following items of glassware are used:

    I. Pipette
    II. Volumetric flask
    III. Conical flask
    IV. Burette

    Which of these items must be rinsed with a *sample* of the solution they will contain *prior* to them being filled with this solution for a titration?

    a) All of them
    b) I and IV.
    c) I, II and IV.
    d) III only.

17. The diagram below shows the level of hydrochloric acid in the burette immediately before and after a titration.



What volume of acid has been used in this titration?

a) 7.0 mL
b) 8.0 mL
c) 8.2 mL
d) 11.6 mL

18. What instrument should be used to accurately measure and deliver exactly 20 mL of the primary standard?

a) A graduated cylinder.
b) An eyedropper.
c) A burette.
d) A pipette.

19. Which one of the following is a reason why potassium permanganate is unsuitable as a primary standard?

a) The exact molecular formula is unknown.
b) Potassium permanganate is an oxidising agent.
c) Solutions of potassium permanganate are unstable and decompose when exposed to light.
d) Its molar mass is too high.

20. Study the following equation for the reaction between concentrated nitric acid and copper metal and then answer the question below.

$$Cu(s) + 4H^+(aq) + 2NO_3^-(aq) \Rightarrow Cu^{2+}(aq) + 2H_2O(l) + 2NO_2(g)$$

The reducing agent is

a) copper metal.
b) nitric acid.
c) hydrogen ions.
d) nitrogen doxide.

21. Which one of the following is a strong oxidising agent, used both as a bleaching agent and in the purification of water?

a) Hydrogen peroxide, H_2O_2.
b) Hypochlorite ion, OCl^-.
c) Hydrogen chloride, HCl.
d) Sulfuric acid, H_2SO_4.

22. What would you expect to observe when chlorine is added to a solution of sodium bromide.

a) The solution would turn red.
b) A purple precipitate would be formed.
c) There would be no reaction.
d) The solution would become green.

23. What is the oxidation number of manganese in the permanganate ion, MnO_4^-?

a) –1 b) +7
c) -7 d) +8

24. Oxidation occurs when

a) a substance donates hydrogen ions.
b) a substance becomes negatively charged.
c) a substance gives up electrons.
d) a substance gains electrons.

25. Which of the following oxides is acidic?

a) Na_2O
b) MgO
c) Al_2O_3
d) SO_2

The next two questions refer to the information below.

In the extraction of iron in the blast furnace, a mixture of iron ore, coke (form of carbon) and limestone is used.
The overall reaction is:

$$Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(s) + 3CO_2(g)$$

26. What is the function of the limestone in the extraction process?

a) It acts as a catalyst in the reaction.
b) Its decomposition at high temperatures provides the calcium oxide and carbon dioxide needed for the extraction process.
c) It forms a layer of slag over the iron to prevent its oxidation.
d) It acts as an insulator of heat.

27. With reference to the above equation, which of the following statements is true?

a) The carbon monoxide acts as a reducing agent.
b) The iron (II) oxide is oxidised in the reaction.
c) The oxidation state of the iron has changed from +2 to 0.
d) The carbon monoxide is reduced in the reaction.

Questions 28 and 29 refer to the information below.

The reaction for the extraction of gold by the 'MacArthur and Forrest ' gold cyanide process is:

$$4Au(s) + 8CN^-(aq) + 2H_2O(l) + O_2(g) \Rightarrow 4[Au(CN)_2]^-(aq) + 4OH^-(aq)$$

28. Which one of the following statements is false?

a) The cyanide ion is used to assist the oxidation of gold.
b) The oxidation state of the gold changes from 0 to +1.
c) Cyanide ions are reduced.
d) The oxygen acts as the oxidising agent in the reaction.

29. To recover the gold from the auro-cyanide ion produced in the above reaction, it is reduced by a displacement reaction with

a) iron.
b) zinc.
c) calcium oxide.
d) magnesium.

30. The ion formed when excess ammonia solution is added to a solution containing copper (II) ions is

a) $[Cu(NH_3)_4]^{2+}$
b) $[Cu(NH_3)_6]^{+}$
c) $[Cu_2(NH_3)_4]^{2+}$
d) $[Cu(NH_3)_2]^{2+}$

END OF PART 1

PART 2 (70 marks = 35% of paper)

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

Question 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) Solid sodium hydroxide is added to dilute hydrochloric acid.

Equation _____

Observation _____

_____

[3 marks]

(b) Dilute ammonia solution is added to sodium hydroxide solution.

Equation _____

Observation _____

_____

[3 marks]

(c) Iron(III) nitrate solution is added slowly to sodium bromide solution.

Equation _____

Observation _____

_____

[3 marks]

(d) Dilute sulfuric acid is added to a solution of potassium chromate.

Equation _____

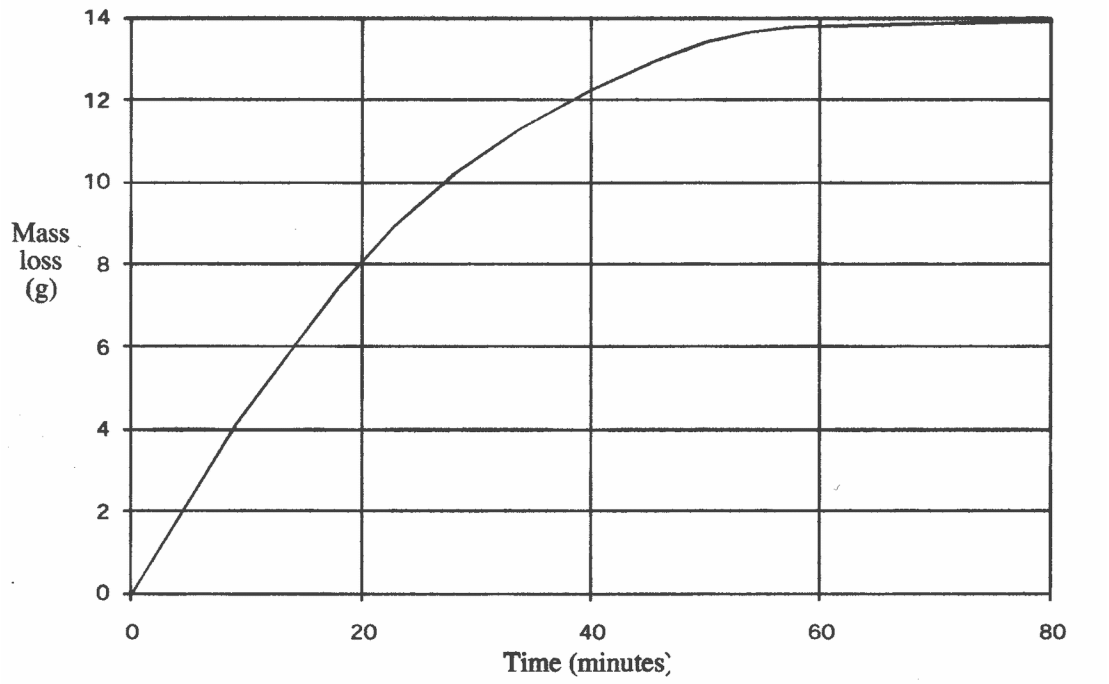
Observation _____

_____

[3 marks]

Question 2

An excess of $CaCO_3$ in the form of large pieces of marble is reacted with 500 mL hydrochloric acid in an open flask standing on a balance. The loss in mass of the contents of the flask as a function of time is shown graphically below.



(a) Write the equation for the reaction which occurs. Why is there a loss in mass of the flask and its contents?

[2 marks]

(b) Calculate the average rate of reaction between 0–20 minutes and also between 20–40 minutes (Take care with units). Explain any difference between these two rates of reaction.

[2 marks]

Why does the mass loss of the contents of the flask not increase after 70 minutes?

(c)

[1 mark]

(d) Explain *clearly* what would have been the effect on the initial rate of reaction if small chips of marble had been used?

[1 mark]

Question 3

A chemical engineer has been given the task of maximising the yield of a chemical process, while minimising the cost of the process.

Assess the range of factors that need to be considered by the engineer. In your answer refer to the Haber process.

[5 marks]

Question 4

Identify by name or formula an example of each of the following

Description	Name or Formula
A positively charged complex ion	
A halogen which is liquid at room temperature and pressure	
A salt that dissolves in water to give an acidic solution	
A weak acid other than acetic acid	
A substance that can be used as a primary standard for redox titrations	
A diprotic acid	
A secondary standard used in many acid-base titrations	

[7 marks]

Question 5

(a) Consider the following reaction:

$$3Cl_{2(g)} + 6NaOH_{(aq)} \rightarrow 5NaCl_{(aq)} + NaClO_{3(aq)} + 3H_2O$$

[4 marks]

What is the oxidation state of

(i) Cl in $Cl_{2(g)}$ .....

(ii) Cl in $NaCl_{(aq)}$ .....

(iii) Cl in $NaClO_{3(aq)}$ .....

(iv) Explain why the above reaction is classified as a disproportionation reaction.

_____

_____

_____

_____

(b) $SO_{2(g)}$ is bubbled into an aqueous solution containing $Fe^{3+}_{(aq)}$ ions. Write half-equations and a balanced overall equation for the chemical changes occurring.

Name the oxidising agent and the reducing agent. **[4 marks]**

Question 6

Many industrial chemical processes involve equilibrium reactions. For example, the gas carbon oxyfluoride (COF_2) decomposes to the gas carbon tetrafluoride (CF_4) and carbon dioxide.

(i) Write a balanced equation for the reaction, and hence write the expression for the equilibrium constant for this reaction.

[2 marks]

The reaction is carried out at 200°C in a fixed-volume 10 litre container. Initially, there are 2.0 moles of carbon oxyfluoride gas in the flask. At equilibrium, 80% of the carbon oxyfluoride has decomposed.

[3 marks]

(ii) Determine the value of the equilibrium constant.

(iii) The enthalpy change for the decomposition of carbon oxyfluoride is –24 kJ mol^{-1}. Explain the effect of an increase in temperature on the equilibrium constant.

[1 mark]

Question 7

Use the information given below to identify the elements X and Y. Justify your choices.

The oxides have formulae of XO and YO_2.
XO is a solid which dissolves in water producing a basic solution.
YO_2 is a colourless, odourless gas which dissolves in water producing an acidic solution.
The element X is the third member of its group in the periodic table.

[3 marks]

Question 8

Consider the equilibrium reaction between hydrogen chloride gas and oxygen gas using a suitable catalyst:

$$4HCl(g) + O_2(g) \quad 2H_2O(g) + 2Cl_2(g) \qquad \Delta H = -280 \text{ kJ mol}^{-1}$$

Complete the table below by:

(a) indicating the change in the **amount** of hydrogen chloride gas (write either "more", "less" or "unchanged") after each of the following changes to conditions at equilibrium have been made.

(b) giving also a brief **reason** for your choice based on accepted chemical principles.

Change imposed on the system	Effect on **amount** of HCl(g) present
1. The temperature of the system is raised.	(a)……..……. (b) Reason…….. …… ……..……
2. The pressure of the system is doubled by halving the volume of the reaction vessel.	(a)…….. (b) Reason……..…… ……..…..…… ……..……
3. The surface area of the **catalyst** is increased	(a)…….…….. (b) Reason……..…… …… ……

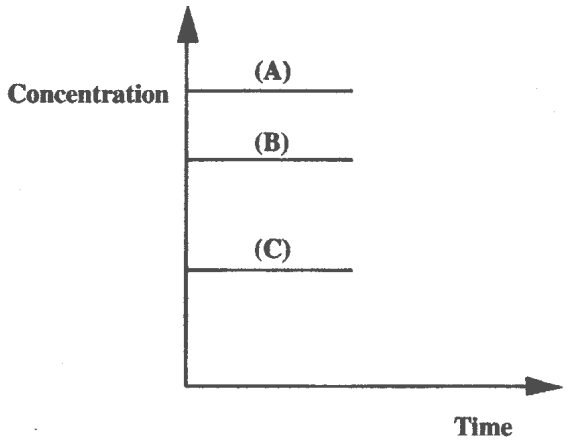
[9 marks]

Question 9

Consider the gaseous system $A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)}$. At equilibrium, a concentration/time graph would look like the graph below.

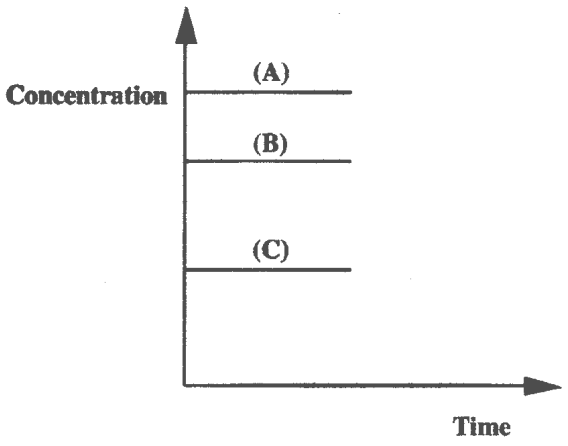
(a) Draw a concentration/time graph to reflect changes if the partial pressure of gas (B) is increased by adding gas (B) at constant volume.

[3 marks]



(b) Draw a concentration/time graph to reflect the changes if the total pressure is decreased by increasing the volume (temperature is held constant).

[3 marks]



SEE NEXT PAGE

Question 10

Consider the equilibrium:

$$BaSO_{4(s)} + H_2O \rightleftharpoons Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$

(a) Why is this described as a **dynamic equilibrium**?

[2 marks]

(b) Given a small amount of $BaSO_{4(s)}$ containing radioactive barium, explain how this could be used in an experiment to show that the equilibrium above is dynamic.

[2 marks]

Question 11

What is the function of carbon in the CIP process?

[1 mark]

_____

_____

_____

Question 12

Hydrazine, N_2H_4, is sometimes used as a rocket fuel. If $F_{2(g)}$ is used as an oxidant, its heat of combustion is:

$$N_2H_4 + 2F_{2(g)} \rightarrow N_{2(g)} + 4HF_{(g)} \quad \Delta H = -1126 kJ\ mol^{-1}.$$

Draw a potential energy diagram for the above reaction.

Show all information on the diagram.

[3 marks]

END OF PART 2

PART 3 (50 marks = 25% of paper)

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, clearly distinguish each section using (a), (b), and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't, you will lose marks.

Question 1

Maria designed an experiment to measure the molar volume of hydrogen gas. To do this she planned to dissolve a carefully weighed piece of pure aluminium in excess hydrochloric acid and collect the resulting hydrogen gas. Since a 1.00 L measuring cylinder is the largest she has at her disposal, determine the maximum mass of pure aluminium Maria should use. Assume the laboratory temperature is 25 ^{o}C and the gas is collected at 100.7 kPa. Water has a vapour pressure of 3.17 kPa at these conditions.

[6 marks]

Question 2

Hydrogen sulfide gas (H_2S) readily dissolves in a sodium hydroxide solution to produce a sodium sulfide solution and water. In an experiment 4.92 g of $H_2S(g)$ is bubbled through 155 mL of 1.100 mol L^{-1} NaOH solution. What maximum mass of Na_2S could be produced in this experiment?

[8 marks]

Question 3

A 2.972 g sample of an unknown metallic element was dissolved in 125.0 mL of 2.107 mol L^{-1} $HNO_3(aq)$. The reaction produced a salt with formula $M(NO_3)_4$.

$$3M(s) + 16HNO_3(aq) \rightarrow 3M(NO_3)_4(aq) + 4NO(g) + 8H_2O(l)$$

The remaining solution which was known to contain excess $HNO_3(aq)$ was diluted to 250.0 mL. A 20 mL sample of the diluted solution containing excess $HNO_3(aq)$ was titrated to equivalence using 32.95 mL of 0.3152 mol L^{-1} $NaOH(aq)$. What is the molar mass of the metal? Use your answer to identify the metal element.

[9 marks]

Question 4

A 4.65 g sample of pure NaOH*(s)* is added to 626 mL of 0.335 mol L^{-1} HCl*(aq)*. Assume the final volume of mixture is unchanged and determine the pH of the mixture when the reaction is complete.

[8 marks]

Question 5

The concentration of the atmospheric pollutant sulfur dioxide (SO_2) can be found by bubbling air through a dilute $KMnO_4(aq)$ solution of known concentration.

$$5SO_2(g) + 2MnO_4^-(aq) + 2H_2O(l) \rightarrow 5SO_4^{2-}(aq) + 2Mn^{2+}(aq) + 4H^+(aq)$$

The concentration of the remaining $KMnO_4(aq)$ can be found by titration with standardised oxalic acid. This allows the amount of $KMnO_4$ reacting with sulfur dioxide to be found and thus its concentration in the air sample can be calculated.
In such a procedure 43.9 m^3 of SO_2 polluted air was bubbled through 215.0 mL of 5.007×10^{-3} mol L^{-1} $KMnO_4(aq)$. The unreacted $KMnO_4$ was acidified and diluted to a volume of 250.0 mL. 20.00 mL samples of this $KMnO_4$ solution were titrated to equivalence with 38.50 mL of 2.194×10^{-3} mol L^{-1} oxalic acid solution.
What is the concentration of the pollutant $SO_2(g)$ in ppm if the air has a density of 1.18 kg m^{-3}?

[12 marks]

Question 6

In a laboratory procedure two students need to make a secondary standard solution of approximately 0.04 mol L^{-1} $KMnO_4(aq)$. To do this they dissolved 3 g of solid $KMnO_4$ in 500 mL of distilled water. The solution was then boiled, filtered through glass wool and stored in a dark bottle away from light.

A second solution of oxalic acid was prepared by dissolving 3.095 g of $H_2C_2O_4.2H_2O(s)$ in water and making its volume up to 250.0 mL in a volumetric flask. Finally, the oxalic acid solution was added to a burette and titrated into 20.00 mL samples of the potassium permanganate solution. The burette readings for the $H_2C_2O_4$ solution were as follows:

Final volume (mL)	22.25	22.91	24.75	22.38
Initial volume (mL)	0.87	1.46	2.75	0.98

Using this information, determine the actual concentration of the approximately 0.04 mol L^{-1} $KMnO_4$ solution.

[7 marks]

PART 4 (20 marks = 10% of paper)

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 for the relevant chemical content of your answer, but also for coherence and clarity of expression. Your answer should be presented in about 1.5 - 2 pages. Begin your essay on the lined page following the end of the questions.

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1. You are to present a series of laboratory sessions on acid-base volumetric analysis. Discuss what you would present and why keeping in mind the importance of good laboratory technique, the correct use of various pieces of equipment and the need for primary and secondary standards.

OR

2. Compare and contrast the reactions involved in the chemical purification and extraction reactions for gold and iron. In what way are the differences in the properties of these two metals evident in the use of the metals in everyday life?

END OF QUESTIONS

END OF PAPER