MERCY COLLEGE

First Semester Examination, 2004

Question/Answer Booklet

YEAR 12 CHEMISTRY

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 for this subject.

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.

Course Coordinator: Malcolm Cesareo

Structure of this paper

Part	Number of questions available	Number of questions to be attempted	Suggested working time	Marks available
1 Multiple choice	30	ALL	55	60 (30%)
2 Short answers	10	ALL	60	70 (35%)
3 Calculations	7	ALL	45	50 (25%)
4 Extended answers	2	1	20	20 (10%)
			Total marks	200 (100%)

Instructions to candidates

1. The rules for the conduct of Tertiary Entrance Examinations are detailed in the booklet *TEE Handbook.* Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions:

Part 1 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 Write your answers in the spaces provided in this Question/Answer Booklet. A blue or black ball point or ink pen should be used.

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.

3. The examiners recommend that you spend your reading time mainly reading the instructions to candidates and Parts 2, 3 and 4.

4. **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), $CH_3COOH(l)$, CH3COOH(aq)] or **solids** [for example $BaSO_4$(s), Cu(s), Na_2CO_3(s)].

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PART 1 (60 marks)

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. A sample of an unknown gas at STP has a density of 1.25 grams per litre. What is the molar mass of this gas?

   (a) 28.0 g
   (b) 44.0 g
   (c) 64.0 g
   (d) 80.0 g

2. What is the net ionic equation for the reaction of HCl(aq) with NaOH(aq)?

   (a) $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$
   (b) $Na^+(aq) + Cl^-(aq) \longrightarrow NaCl(s)$
   (c) $HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$
   (d) $2H^+(aq) + 2OH^-(aq) \longrightarrow 2H_2(g) + O_2(g)$

3. At 20°C and 101.3 kPa, 3.9 g of methane occupies 5.88 L. If the same volume of another gaseous hydrocarbon at the same temperature and pressure has a mass of 10.7 g, the gas could be

   (a) C_2H_4
   (b) C_2H_6
   (c) C_3H_8
   (d) C_4H_{10}

4. The ion concentrations in 0.25 mol L^{-1} $Al_2(SO_4)_3$ are

	$[Al^{3+}]$	$[SO_4^{2-}]$
(a)	0.25 mol L^{-1}	0.25 mol L^{-1}
(b)	0.50 mol L^{-1}	0.75 mol L^{-1}
(c)	0.75 mol L^{-1}	0.50 mol L^{-1}
(d)	0.10 mol L^{-1}	0.15 mol L^{-1}

5. What is observed when H_2SO_4 is added to a saturated solution of $CaSO_4$

   (a) the pH increases
   (b) the $[Ca^{2+}]$ increases
   (c) bubbles of H_2 are given off
   (d) additional $CaSO_4$ precipitates

SEE NEXT PAGE

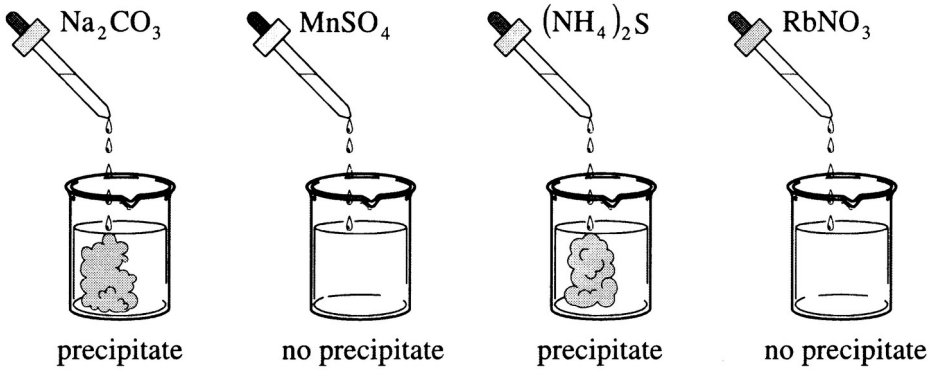
6. Which of the following will NOT produce a precipitate when equal volumes of 0.20 mol L^{-1} solutions are combined?

   (a) KOH and $CaCl_2$
   (b) $Zn(NO_3)_2$ and K_3PO_4
   (c) NaOH and $(NH_4)_2S$
   (d) Na_2SO_4 and $Pb(NO_3)_2$

7. A 200.0 mL solution contains 0.050 mol of $Ba(NO_3)_2$. The concentration of nitrate ions is

   (a) 0.050 mol L^{-1}
   (b) 0.10 mol L^{-1}
   (c) 0.25 mol L^{-1}
   (d) 0.50 mol L^{-1}

8. An experiment is conducted to identify an unknown cation that is present in each of four beakers.



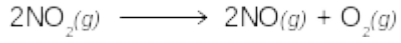
   Which of the following could be the unknown cation?

   (a) Ag^+
   (b) Be^{2+}
   (c) Ba^{2+}
   (d) K^+

9. An activated complex is a chemical species that is

   (a) stable and has a low potential energy
   (b) stable and has a high potential energy
   (c) unstable and has a low potential energy
   (d) unstable and has a high potential energy

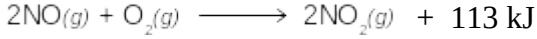
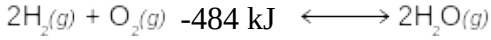
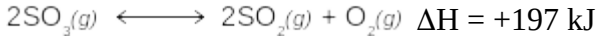
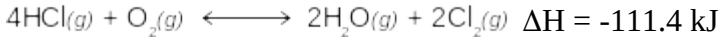
10. Consider the following reaction:



   Under certain condition, the rate of decomposition of NO_2 is 3.2×10^{-3} mol/s. The rate of formation of O_2 is

   (a) 1.6×10^{-3} mol/s
   (b) 3.2×10^{-3} mol/s
   (c) 4.8×10^{-3} mol/s
   (d) 6.4×10^{-3} mol/s

11. Which of the following reactions is accompanied by an increase in enthalpy?

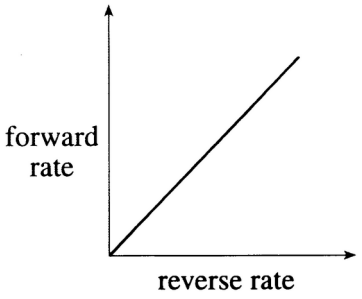
   (a) 
   (b) 
   (c) 
   (d) 

12. Consider the following reaction:

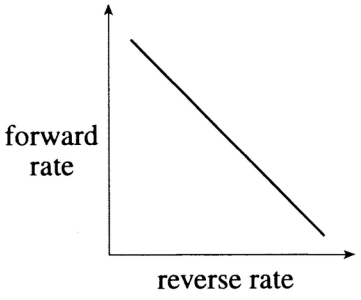
$$N_2(g) + 3H_2(g) \longleftrightarrow 2NH_3(g)$$

Which of the following diagrams represents what happens to the forward and reverse reaction rates when the catalyst Fe_3O_4 is added?

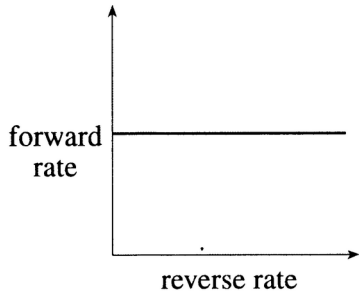
A.



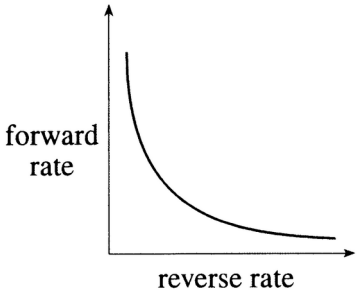
B.



C.



D.



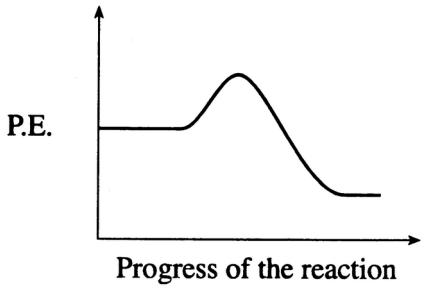
13. Hydrogen gas dissociates into atomic hydrogen as follows:

$$H_2(g) \longleftrightarrow 2H(g) \qquad K = 1.2 \times 10^{-71}$$

The value of the equilibrium constant for the above system indicates that

(a) the reaction rate is very slow
(b) the equilibrium is exothermic
(c) reactants are favoured at equilibrium
(d) a catalyst is necessary to establish equilibrium

14. Consider the following potential energy diagram for an equilibrium system:



When the temperature of the system is increased, the equilibrium shifts to the

(a) left and K increases
(b) left and K decreases
(c) right and K increases
(d) right and K decreases

15. Consider the following equilibrium system:

$$CaCO_{3(s)} \longleftrightarrow CaO_{(s)} + CO_{2(g)}$$

Which one of the following changes would cause the above system to shift left?

(a) add more CaO
(b) remove $CaCO_3$
(c) decrease volume
(d) increase surface area of CaO

16. Oxides of nitrogen are formed in air at the high temperatures generated in lightning flashes according to the equation

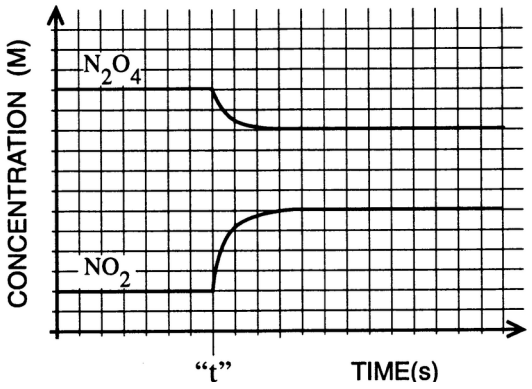
$$N_{2(g)} + O_{2(g)} \longleftrightarrow 2NO_{(g)} \quad K = 5 \times 10^{-3} \text{ at } 3000^oC$$

At 3000ºC, the equilibrium constant for the reaction $2NO_{(g)} \longleftrightarrow N_{2(g)} + O_{2(g)}$ would be

(a) 4×10^4
(b) 2×10^2
(c) 2×10^{-2}
(d) 5×10^{-3}

17. Consider the following concentration versus time graph for the equilibrium:

$N_2O_4(g) \longleftrightarrow 2NO_2(g)$



At time = "t", which of the following disturbances occurred?

(a) catalyst was added
(b) pressure was changed
(c) temperature was changed
(d) concentration of NO_2 was changed

18. What is the pH of a solution prepared by adding 0.50 mol KOH to 1.0 L of 0.30 mol L^{-1} HNO_3?

(a) 0.20
(b) 0.70
(c) 13.30
(d) 13.80

19. Separate solutions of the following salts are prepared, each solution having a concentration of 0.10 mol L^{-1}. Which solution has the highest pH?

(a) KCl
(b) NaF
(c) $Pb(NO_3)_2$
(d) NH_4Cl

20. The conjugate base of $H_2BO_3^-$ is

(a) HBO_3^{2-}
(b) H_3BO_3
(c) $H_3BO_3^-$
(d) BO_3^{3-}

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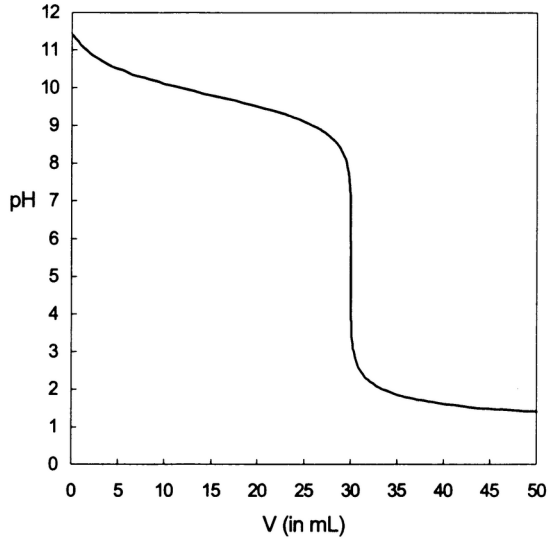
21. The titration curve illustrated below corresponds to which type of titration?



(a) weak base by weak acid
(b) weak acid by strong base
(c) strong base by strong acid
(d) weak base by strong acid

22. Consider the following redox reaction:

$$2Cr^{3+}(aq) + 3Cl_2(aq) + 7H_2O(l) \longrightarrow Cr_2O_7^{2-}(aq) + 6Cl^-(aq) + 14H^+(aq)$$

The species which loses electrons is

(a) Cl_2
(b) Cr^{3+}
(c) H_2O
(d) $Cr_2O_7^{2-}$

23. Which of the following represents a redox reaction?

(a) $H_2CO_3 \longrightarrow H_2O + CO_2$
(b) $CuS + H_2 \longrightarrow H_2S + Cu$
(c) $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$
(d) $2HCl + Na_2SO_3 \longrightarrow 2NaCl + H_2O + SO_2$

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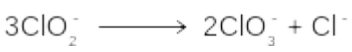
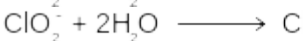
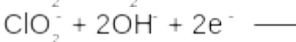
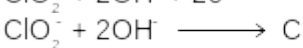
24. Consider the following redox reaction:

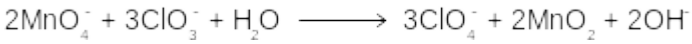


(basic)

The reduction half-reaction that occurs is

(a) 
(b) 
(c) 
(d) 

25. Consider the following redox reaction:



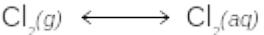
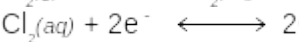
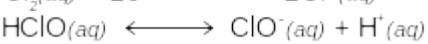
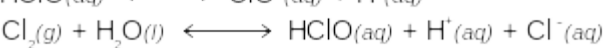
The reducing agent is

(a) H_2O
(b) ClO_3^-
(c) MnO_2
(d) MnO_4^-

26. As SO_4^{2-} changes to SO_3^{2-}, it is said that sulfur is being reduced since its oxidation number

(a) increases as electrons are lost
(b) decreases as electrons are lost
(c) increases as electrons are gained
(d) decreases as electrons are gained

27. In the chemistry world, pool “chlorine” is the following equilibrium system:

(a) 
(b) 
(c) 
(d) 

28. Gold is separated from ore by oxidizing the gold using which oxidizing agent?

(a) O_2
(b) $Cr_2O_7^{2-}$
(c) H_2O
(d) CN^-

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29. In the extraction of iron using the blast furnace technique, the production of carbon monoxide occurs because of the presence of

    (a) suitable catalysts
    (b) limited air
    (c) limited carbon
    (d) both (b) and (c)

30. In the blast furnace for iron production

    (a) SiO_2 reacts with CaO to form a low density slag
    (b) SiO_2 reacts with CaO to form a high density slag
    (c) SiO_2 reacts with $CaCO_3$ to form a high density slag
    (d) SiO_2 reacts with $CaCO_3$ to form a low density slag

END OF PART 1

PART 2 (70 marks)
Answer ALL questions in Part 2 in the spaces provided below.

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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 must state this as the observation.

(a) Dilute hydrochloric acid is added to solid sodium carbonate.

Equation _____

Observation _____

_____

[3 marks]

(b) An excess of ammonia is slowly added to solid zinc hydroxide.

Equation _____

Observation _____

_____

[3 marks]

(c) Dilute sodium hydroxide is added to a small amount of chromium metal.

Equation _____

Observation _____

_____

[3 marks]

(d) Hot concentrated sulphuric acid is added to a piece of copper.

Equation _____

Observation _____

_____

[3 marks]

SEE NEXT PAGE

2. (a) Write ionic equations for the combination of the following solutions:

(i) copper(II) sulfate and lithium sulfide [1 mark]

_____

(ii) magnesium chloride and silver nitrate [1 mark]

_____

(iii) acetic acid and sodium hydroxide [1 mark]

_____

(iv) ammonia and sulfuric acid [1 mark]

_____

(v) sodium sulfate and barium nitrate [1 mark]

_____

(b) Balance the following equation by giving the values of the coefficients: W, X, Y and Z:

$\underline{W}$ Al(s) + $\underline{X}$ Fe_3O_4(s) -------> $\underline{Y}$ Al_2O_3(s) + $\underline{Z}$ Fe(s) [2 marks]

W = _____

X = _____

Y = _____

Z = _____

(c) Write a chemical equation that shows the dissociation of calcium chloride. [1 mark]

_____

(d) What is the pCl of a 0.01 M solution of NaCl? _____ [1 mark]

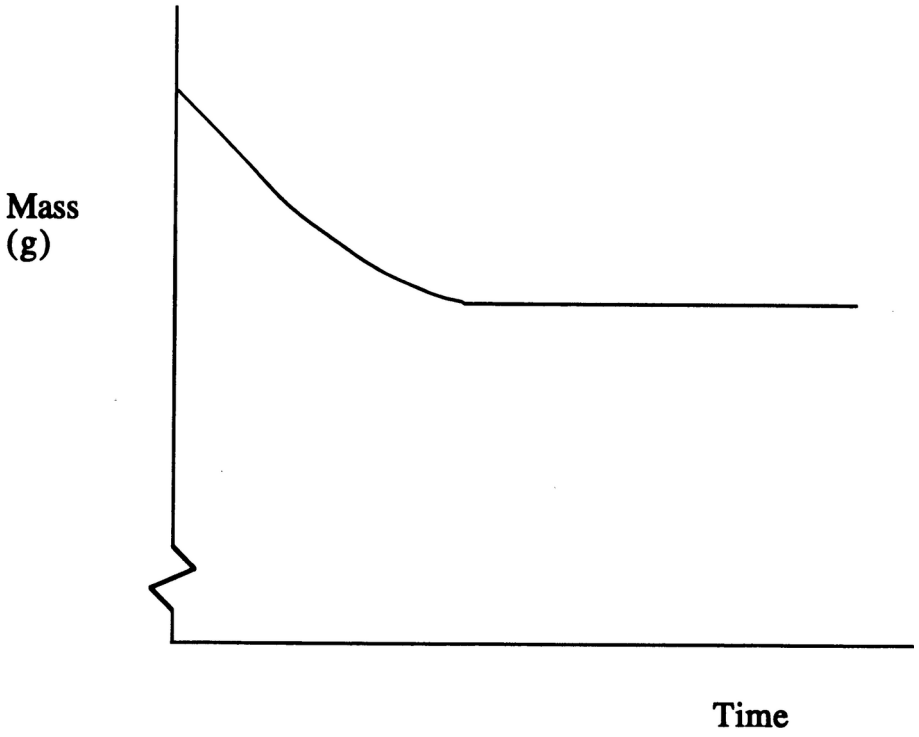
3. Using the collision theory, explain why a mixture of natural gas and air does not react at room temperature but explodes when a piece of platinum is placed in the gas mixture.

[3 marks]

4. 10.0 g of scrap copper water pipe was dissolved in a beaker containing 500 mL of 2.00 mol L^{-1} nitric acid according to the following equation:

$$3Cu_{(s)} + 8HNO_{3(aq)} \longrightarrow 3Cu(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$$

The changing mass of the mixture was observed against time, and the following graph obtained:



(a) On the graph sketch the expected curve if 500 mL of 1.00 mol L^{-1} nitric acid had been used instead. Label your new graph line.

[2 marks]

Explain the difference in shape.

_____

_____

_____

_____

_____

(b) Show on the graph the expected line if the 10.0 g of scrap copper had previously been ground up in a hammer mill. Label this graph line. Explain.

[2 marks]

_____

_____

_____

_____

_____

5. A nitrogen dioxide molecule can collide with a carbon monoxide molecule as follows:

$$NO_2 + CO \longrightarrow NO + CO_2$$

(a) For this reaction, $\Delta H = -225$ kJ mol^{-1} and the activation energy is 125 kJ mol^{-1}. What is the activation energy for the reverse reaction?

[1 mark]

_____

(b) What energy changes take place as the nitrogen dioxide and carbon monoxide molecules approach each other?

[2 marks]

_____

_____

_____

6. Consider the following steps in a chemical reaction:

Step 1: $NO_{(g)} + O_{3(g)} \longrightarrow NO_{2(g)} + O_{2(g)}$
Step 2: $O_{(g)} + NO_{2(g)} \longrightarrow NO_{(g)} + O_{2(g)}$

Which species is the catalyst? Explain.

[2 marks]

7. Sufficient hydrogen chloride gas an oxygen gas are introduced into a container and the temperature held constant at 450°C, and the pressure adjusted to 101.3 kPa until equilibrium is attained, according to the reaction:

$4HCl_{(g)} + O_{2(g)} \longleftrightarrow 2H_2O_{(g)} + 2Cl_{2(g)}$ $\Delta H = -117.6$ kJ

(a) Write an expression for the equilibrium constant, K. [1 mark]

(b) How will the equilibrium constant at 550°C compare with the value at 450°C (the pressure remaining constant at 101.3 kPa)? Explain.

[3 marks]

(c) The volume is expanded at constant temperature so that the pressure is decreased. The system is allowed to resettle to equilibrium. How will the concentration of the reactant gases and product gases at this new equilibrium compare with their concentrations at the initial equilibrium? Give reasons.

[3 marks]

(d) Compare K of part (c) above to the initial value of part (a). [1 mark]

(e) For the similar equilibrium between hydrogen bromide gas and oxygen:

$$4HBr_{(g)} + O_{2(g)} \longleftrightarrow 2H_2O_{(g)} + 2Br_{2(g)}$$

What property of the system could you make use of in order to determine any change in the position of the equilibrium?

[1 mark]

(f) What is “equal” in a chemical reaction that has reached a state of equilibrium?

[2 marks]

8. Use half equations to balance the following equation in a basic environment. Make sure all working is shown. Marks will also be awarded for clear indication of oxidation numbers for each of the atoms in the equation.

$$FeO_4^{2-}(aq) + NH_3(aq) \longrightarrow N_2(g) + Fe^{3+}(aq)$$

[12 marks]

9. (a) Why is hypochlorous acid able to destroy algae and bacteria in water? Why is it more effective than hypochlorite ion?

[2 marks]

_____

_____

_____

(b) What are the three raw materials fed into a blast furnace?

[3 marks]

_____

_____

(c) Write the chemical equation that takes place by the BOS for the removal of silicon in pig iron.

[1 mark]

_____

10. (a) Write an equation to show the production of the main contaminant that is often found in storage bottles containing potassium permanganate solutions.

[2 marks]

_____

_____

_____

(b) Describe the procedure used to prepare a potassium permanganate solution. Explain why the various steps are taken.

[6 marks]

_____

_____

_____

_____

_____

_____

END OF PART 2

SEE NEXT PAGE

PART 3 (50 marks)

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.

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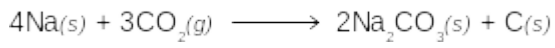
1. Calculate the density of NO_2 gas at 1.00 atm and 35°C.

[3 marks]

2. A 16.0 mol L^{-1} solution of nitric acid contains 70% HNO_3 by mass. Calculate the density of the solution.

[4 marks]

3. 3.72 litres of carbon dioxide gas at 27°C at 154.2 kPa has 4.52 grams of sodium added to it. The sodium is ignited and reacts with the carbon dioxide according to the following equation:



$$4Na_{(s)} + 3CO_{2(g)} \longrightarrow 2Na_2CO_{3(s)} + C_{(s)}$$

Calculate the mass of sodium carbonate produced and the number of moles of excess reagent remaining after the reaction.

[6 marks]

4. A particular ore contains 47.2% MnO_2. What mass of the ore must be refined to produce 2.50 tonnes of pure manganese metal?

[6 marks]

5. A chemist wants to determine the percentage of cerium(III) and cerium(IV) in a sample containing $Ce(NO_3)_3$, $CeCl_4$ as well as some non-cerium impurities. He dissolves 2.167 grams of the sample in water and adds potassium bromate to oxidise all cerium(III) to cerium(IV). Enough potassium iodate is then added to precipitate out the cerium(IV) as cerium(IV) iodate, $Ce(IO_3)_4$. He collects the solid by filtration and places the solid with its filter paper into a beaker. To this he adds a quantity of oxalic acid, $C_2H_2O_4$, in order to remove iodine from the system. The chemical reaction that takes place is as follows:

$$Ce(IO_3)_4(s) + 10C_2H_2O_4(aq) \longrightarrow 2I_2(g) + CeO_2(s) + 10H_2O(l) + 20CO_2(g)$$

The system is boiled to make sure all dissolved iodine is removed. It is then filtered to collect the solid. The solid CeO_2 is placed in an oven at 500°C to drive off any organic impurities. The solid CeO_2 is then weighed and found to have a mass of 2.312 grams.

The chemist then takes 1.528 grams of the original sample and analyses it for its nitrate content. The mass of the nitrate ion in this quantity is found to be 0.5230 grams.

(a) Calculate the percentage by mass of cerium(III) as well as the percentage by mass of cerium(IV) in the original sample.

[11 marks]

(b) Calculate the pressure (in kPa) of iodine gas generated if it is collected during the procedure and occupies a volume of 255.4 ml at 25°C.

[2 marks]

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6. The nitrogen content of a 0.895 g sample of dried protein was determined by converting all the nitrogen in the protein into ammonia gas. The ammonia was then bubbled through 50.0 ml of 0.1970 mol L^{-1} hydrochloric acid causing a reaction to occur between the two species. After the ammonia had reacted there was some hydrochloric acid remaining. This was neutralised by titrating with 5.90 ml of 1.028 mol L^{-1} sodium hydroxide solution. Calculate the percentage by mass of nitrogen in the sample of dried protein. In this question marks will be allocated for chemical equations shown.

[10 marks]

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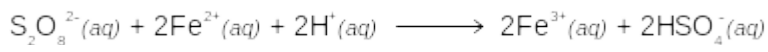
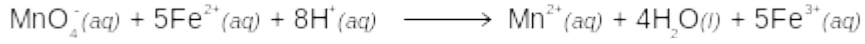
7. A solution is to be analysed for its potassium persulfate content by a titration technique. A volume of 50 ml is pipetted from the solution into a 500 ml flask which is then made up to the mark with distilled water. An aliquot of 25 ml of this diluted solution is placed into a conical flask. 50 ml of 0.0931 mol L^{-1} $FeSO_4$ in an acidic environment is also added to the flask so that all the persulfate is reduced as described by the following equation:



The excess iron(II) that remains after the reaction is titrated against 0.0194 mol L^{-1} potassium permanganate. The volume of permanganate at the end point is found to be 21.08 ml. The following equation describes the reaction:



From this information calculate the concentration of potassium persulfate in the original solution.

[8 marks]

END OF PART 3

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PART 4 (20 marks)

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. "The industrial production of compounds is a compromise between reaction rate requirements, equilibrium requirements and economic requirements." Explain this statement using as examples the processes and conditions used in the Haber and Contact processes. Make sure you explain the chemistry behind the statements you have made.

OR

2. Give a detailed account of the laboratory procedures that you would use to determine the percentage by mass of acetic acid in vinegar. Your response must include the preparation/analysis of primary and secondary standards. Furthermore, include in your answer any relevant chemical equations. Identify sources of error in the procedure and describe how you would minimise such errors. You are NOT required to give an example of the calculations involved in this analysis.

END OF QUESTIONS

Check that you have written your Name on the front cover of this booklet

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Write your response to Part 4 below.

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