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

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

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR
This Question Answer Booklet comprising **37** pages
Separate Multiple Choice Answer Sheet
Separate Chemical Data Sheet (inside front cover of this Question/Answer Booklet)

TO BE PROVIDED BY THE CANDIDATE
Standard Items: Pens, pencils, eraser, ruler.
Special Items: A calculator 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

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.

PART	FORMAT	NO. OF QUESTIONS SET	NO OF QUESTIONS TO BE ATTEMPTED	MARKS	RECOMMENDED TIME (APPROX)/ MINUTES
1	Multiple Choice	30	ALL	60 (27%)	55
2	Short Answers	12	ALL	98 (43%)	60
3	Calculations	5	ALL	48 (21%)	45
4	Extended Answers	2	1	20 (9%)	20

Total marks for paper = 226 (100%)

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INSTRUCTIONS TO CANDIDATES

This paper consists of **FOUR PARTS** as follows:

PART 1: Multiple Choice

Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet. Use a 2B, B or HB PENCIL to shade in the boxes on the answer sheet. **DO NOT USE A BALL POINT OR INK PEN.**

If you consider that two or more of the alternative answers 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 make sure that your name is on your question Answer/Booklet and 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 $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

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PART 1 – MULTIPLE CHOICE

Answer ALL questions in Part 1 on the Separate Multiple Choice Answer Sheet. Use a 2B, B or HB PENCIL to shade in the boxes on the answer sheet. DO NOT USE A BALL POINT OR INK PEN. This part consists of 60 marks with each question worth 2 marks. It is 27% of the paper and should take 55 minutes.

1. Which of the following has the highest boiling point?

A. CH_3CH_2OH
B. $CH_3CH_2CH_2OH$
C. $CH_3CH_2CH_2CH_3$
D. $CH_3C(O)CH_3CH_2$

2. Which of the following bonds is the most polar?

A. H-H
B. H-C
C. C-F
D. C-Cl

3. How many lone pairs are found in the entire molecule PBr_5?

A. none
B. 5
C. 15
D. 20

4. The strongest intermolecular force between Xe atoms is the

A. nuclear force.
B. dipole-dipole force.
C. hydrogen bonding force.
D. dispersion force.

5. An aqueous solution of calcium chloride is 15.0% by mass $CaCl_2$. If the solution has a density of 1.12 g/mL, the concentration of the solution is

A. 1.28 M
B. 1.35 M
C. 1.51 M
D. 1.68 M

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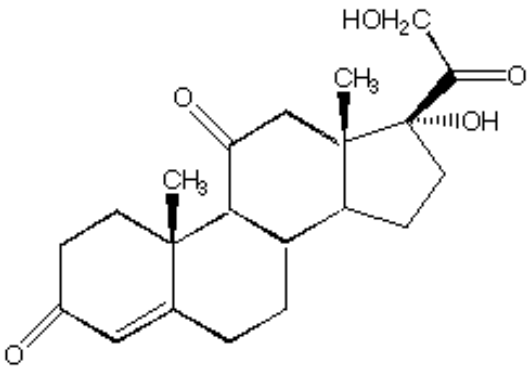
6. How is the equilibrium constant for an exothermic reaction affected by an increase in temperature of the system?

A. The equilibrium constant becomes larger.
B. The equilibrium constant becomes smaller.
C. There is no change in the equilibrium constant.
D. There is no way to determine the effect.

7. Which of the following is a conjugate acid of $HONH_2$?

A. $HONH_3^+$
B. $HONH_2$
C. $HONH^-$
D. HON^{2-}

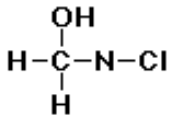
8. Cortisone

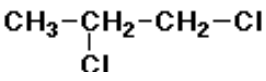


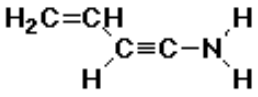
contains which functional groups?

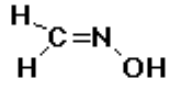
A. Ester, alkene, alcohol
B. Alcohol, ketone, amine
C. Alcohol, ketone, alkene
D. Ester, amine, ketone

9. The only structure that does NOT have an error is:

A. 

B. 

C. 

D. 

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10. What type of reaction is $CH_3OH + HCl \text{ -----> } CH_3Cl + H_2O$

A. acid / base
B. oxidation / reduction
C. addition or elimination
D. substitution

11. How many d electrons are there in the $[Mn(H_2O)_6]^{2+}$ complex?

A. 5
B. 6
C. 7
D. 8

12. Identify the oxidizing agent in the reaction:

$$2Al(s) + 6\ H^+(aq) \text{ -----> } 2\ Al^{3+}(aq) + 3\ H_2(g)$$

A. Al
B. H^+
C. Al^{3+}
D. H_2

13. When dissolved in water, which of the following salts will produce a basic solution?

A. $NaCH_3COO$
B. KNO_3
C. NH_4NO_3
D. NaCl

14. Which of the following would NOT increase the rate of reaction?

A. adding a catalyst
B. increasing the concentration of reactants
C. increasing the surface area of a solid reactant
D. increasing the volume of the container for a gaseous reaction.

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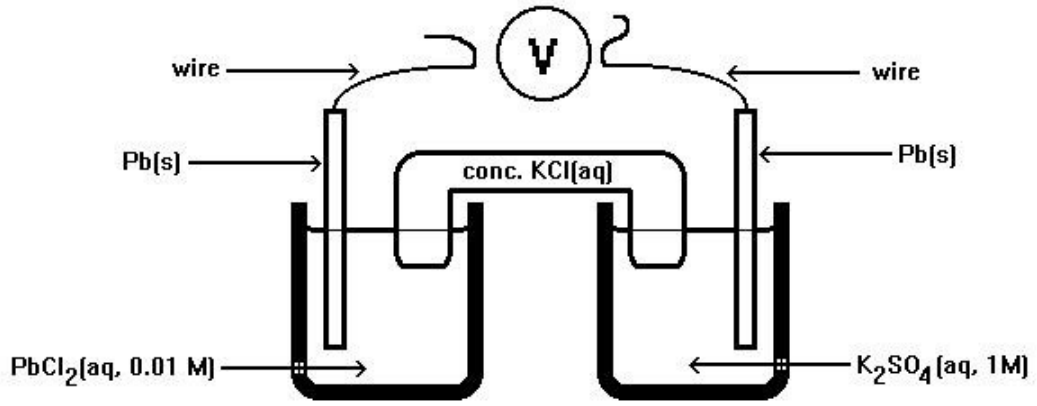
15. A voltaic cell is carefully assembled as shown below, however the electrodes are not yet connected to the voltmeter. Once the circuit is closed, which one of the following statements will be incorrect about the voltaic cell at 25 °C?



A. The net cell reaction is Pb^{2+} (aq) + SO_4^{2-} (aq) -----> $PbSO_4$ (s)
B. Over time, a white precipitate will begin to form in the half cell on the left.
C. Over time, a white precipitate will begin to form in the half cell on the right.
D. Potassium ions will flow into the half-cell on the left.

16. What will be the overall reaction for the electrolysis of an aqueous solution of $Cu(NO_3)_2$ with an inert cathode and a gold anode?

A. $2Au(s) + 6H_2O(l) \rightarrow 2Au^{3+} + 3H_2(g) + 6OH^-$
B. $3Cu^{2+}(aq) + 2NO^{3-}(aq) + 8H^+(aq) \rightarrow 3Cu(s) + 4H_2O(l) + 2NO(g)$
C. $2Cu^{2+}(aq) + 2H_2O(l) \rightarrow 2Cu(s) + O_2(g) + 4H^+$
D. $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

17. The shape of the molecule BCl_3 is

A. planar triangular (same as trigonal planar)
B. linear
C. tetrahedral
D. none of these

18. The entity $ClCH=CH_2$ in the manufacturing of polyvinyl chloride is called

A. a branched polymer
B. a monomer
C. a repeating unit
D. a straight polymer

SEE NEXT PAGE

19. Hydrolysis of esters in the presence of a base produces

A. Detergent
B. Glycerine
C. Fat
D. Soap

20. The pH of a solution with $[OH^-] = 1.5 \times 10^{-4}$ is between

A. 4 and 5
B. 5 and 6
C. 10 and 11
D. 12 and 13

21. Consider the following system at a dynamic equilibrium:

$$CH_4(g) + 2O_2(g) \rightleftharpoons CO_2(g) + 2H_2O(l) \qquad \Delta H = -890 \text{ kJ}$$

Which of the following stresses on the system does *not* increase the partial pressure of CO_2?

A. add heat to the system
B. increase the partial pressure of O_2
C. increase the partial pressure of $CH_4(g)$
D. decrease the volume of the reaction vessel

22. Which of the following is *not* a Bronsted conjugate acid-base pair?

A. F^-/HF
B. NH_2^-/NH_3
C. $H_3O+/OH-$
D. $CH_3NH_3^+/CH_3NH_2$

23. In the discharge of the lead-acid (automobile) battery, all of the following are true *except*

A. PbO_2 is the reducing agent
B. at the anode: $Pb(s) + H_2SO_4(aq) \rightleftharpoons PbSO_4(s) + 2H^+(aq) + 2e-$
C. the electrolyte is sulfuric acid
D. the density of the electrolyte decreases

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24. The loss of metal through corrosion is a major industrial and domestic problem. Which statement regarding the study of corrosion is *incorrect*?

A. The oxidizing agent for the corrosion of iron to form rust is oxygen.
B. Galvanized steel is more resistant to corrosion than unprotected steel because the zinc coating has a lower reduction potential than does the iron of the steel.
C. To protect underground steel pipelines and storage tanks by a redox reaction, the pipeline/storage tank is set up as the anode.
D. Tin-coated steel is more resistant to corrosion than unprotected steel because the tin forms a metal layer through which the oxygen cannot penetrate, much like characteristics of paint or tar.

25. Which of the following is the strongest reducing agent?

A. Na^+
B. Au^+
C. Ag
D. Al

26. All of the following relate to the commercial production of aluminum from its ore (bauxite) *except*

A. $Al^{3+}(aq) + 4OH^-(aq) \rightleftharpoons Al(OH)_4^-(aq)$

B. $Fe^{3+}(aq) + 3OH^-(aq) \rightleftharpoons Fe(OH)_3(s)$

C. $2AlCl_3(l) \rightleftharpoons 2\ Al(l) + 3\ Cl_2(g)$

D. Na_3AlF_6

27. Which of the following describes an electrochemical cell?

	E^o_{cell}	Type of Reaction
A.	Positive	Spontaneous
B.	Positive	Non-Spontaneous
C.	Negative	Spontaneous
D.	Negative	Non-Spontaneous

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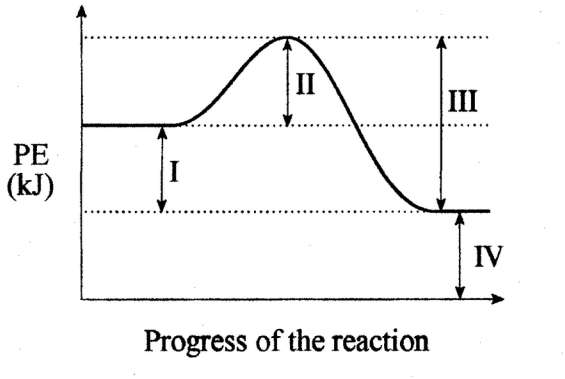
28. Consider the following Potential Energy (PE) diagram:



The heat of reaction for the forward process is represented by

A. I
B. II
C. III
D. IV

29. Which series is ranked in order of increasing electronegativity?

A. O, S, Se, Te
B. Cl, S, P, Si
C. In, Sn, N, O
D. C, Si, P, Se

30. The reducing agent for the commercial production of iron in the blast furnace is

A. calcium carbonate
B. carbon dioxide
C. carbon monoxide
D. calcium silicate

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PART 2 – SHORT ANSWERS

This part consists of 12 questions worth 98 marks. It is 43% of the paper and should take 60 minutes. Answer ALL questions in Part 2 in the spaces provided <u>using a ball-point pen only</u>.

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
(i) colours
(ii) odours
(iii) precipitates (give the colour)
(iv) gases evolved (give the colour or describe as colourless)

If no change is observed, you should state this.

(i) Drops of concentrated HCl solution are added to 1 mL of 0.1 mol L^{-1} $CuSO_4$ solution.

[3 marks]

Equation _____

Observation _____

_____

(ii) 2mL 3-methyl-1-butanol is added to 2 mL ethanoic acid with 5 drops concentrated H_2SO_4. The entire system is heated gently for about 15 minutes.

[3 marks]

Equation

Observation _____

_____

SEE NEXT PAGE

(iii) 5 drops of acidified $KMnO_4$ is added to a test tube containing 2-methyl-2-propanol.

[3 marks]

Equation

Observation _____

_____

(iv) A small piece of sodium is added to 2 mL of ethanol.

[3 marks]

Equation

Observation _____

_____

Question 2

Write a chemical equation which is consistent with the observation in each of the following experiments.

(i)

What is done	Observation	Equation
An acid is added to a yellow solution	The solution turns orange	

(ii)

What is done	Observation	Equation
Sodium chloride is added to a pink solution	The solution turns blue	

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[6 marks]

(iii)

What is done	Observation	Equation(s)
Ammonia is added drop-wise to a blue solution.	A green solid is initially produced. This is followed by the disappearance of the solid and the formation of a deep blue solution.	

[6 marks]

Question 3

What elements have are composed of atoms having the following electron configurations?

(i) $1s^2 2s^2 2p^6 3s^2 3p^4$ _____

(ii) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$ _____

(iii) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^3$ _____

(iv) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^4$ _____

[4 marks]

Question 4

Element X has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$.

(i) What is element X? _____

[1 mark]

(ii) To what group and to what period does this element belong? _____

[2 marks]

SEE NEXT PAGE

(iii) Classify the element as a metal or non-metal _____

[1 mark]

(iv) List the properties associated with the classification you chose

_____

_____

_____

_____

[3 marks]

(v) Draw the electron dot diagram for an atom of element X

[1 mark]

(vi) List two other elements that are likely to be similar in properties to element X

_____

[2 marks]

(vii) If the element gained electrons to achieve a stable octet, how many electrons would it gain? To which element would its ion be most similar in outer-level electron arrangement?

_____

_____

[2 marks]

SEE NEXT PAGE

Question 5

(i) Explain the differences in the six ionisation energies of carbon which are as follows:

Ionisation Energies for Carbon (kilojoules per mole)					
1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}
1086.5	2390	4620	6220	37820	46990

_____

_____

_____

[1 mark]

(ii) Identify the group(s) or class(es) of elements that are most clearly identified with each of the following characteristics:

(a) have partially filled d subshell _____

(b) have completely filled s and p subshells _____

(c) have loosely held single s electron _____

(d) have half-filled p subshell _____

(e) gain one electron to attain a noble gas configuration _____

(f) have an outer energy level with a principal quantum number of 4 _____

(g) have 1, 2 or 3 electrons in the outer energy level _____

(h) have 5, 6, or 7 electrons in the outer energy level _____

(i) generally lose electrons to satisfy the octet rule _____

(j) have an electron dot diagram with seven dots _____

[10 marks]

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Question 6

For each species listed in the table below

(a) draw the electron dot diagram

(b) name the shape of each species

Species	Electron dot diagram	Shape
NO_2^-		
NF_3		

[6 marks]

Question 7

(i) Explain how a molecule can be nonpolar, yet contain polar bonds. Give an example.

_____

_____

_____

_____

_____

[2 marks]

SEE NEXT PAGE

(ii) Determine whether each of the following would more likely be formed by polar or non-polar molecules.

Substance	Polar or Nonpolar?
a solid at room temperature	
a liquid with a high boiling point	
a gas at room temperature	
a liquid with a low boiling point	

[4 marks]

Question 8

Write equilibrium constant expressions for the following reactions:

(i) $NH_2COONH_4(aq) \rightleftharpoons CO_2(g) + 2NH_3(g)$

K_{eq} =

(ii) $4HCl(aq) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(l)$

K_{eq} =

(iii) $NH_4HS(l) \rightleftharpoons NH_3(g) + H_2S(g)$

K_{eq} =

(iv) $CuSO_4.5H_2O(s) \rightleftharpoons CuSO_4(aq) + 5H_2O(l)$

K_{eq} =

[4 marks]

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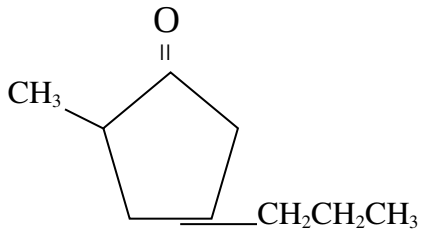
Question 9

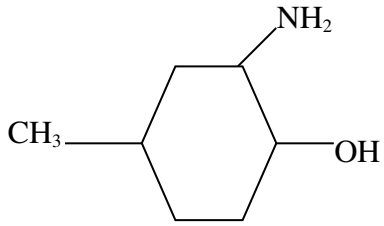
Give the IUPAC name for the following substances:

(i)



_____

(ii)



_____

(iii) $CH_3CH_2CH_2COOCH_3$

_____

[6 marks]

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Question 10

(i) Write an equation to show the reaction that happens when benzoic acid is dissolved in methanol and the mixture is heated in the presence of a little sulfuric acid. Name the product formed.

[4 marks]

(ii) Write an equation to show the condensation polymerisation of 1,3-diaminopropane and octandioic acid

[6 marks]

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Question 11

The five solid compounds listed below are in separate bottles. The following materials are available for distinguishing the compounds: water, litmus paper, HCl(aq), NaOH(aq) and NH_3(aq). Explain how you would distinguish each substance from the others. (Give chemical equations when appropriate.) Assume there are adequate quantities of materials allowing you to do several tests on them.

[10 marks]

(i) $AgNO_3$ (ii) $CuSO_4$ (anhydrous) (iii) $BaSO_4$ (iv) $Zn(OH)_2$ (v) NH_4Cl

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Question 12

The molecular weight of a monoprotic acid can be determined by dissolving a weighed amount of the dried material in distilled water and titrating the solution to a phenolphthalein endpoint with a standard sodium hydroxide solution.

Predict how the calculated molecular weight would compare with the true value (higher, lower or the same) for each of the following changes in the procedure.

Change in Procedure	Prediction (higher, lower or the same)
The original sample is not dried completely before weighing.	
The sample is dissolved in 150 mL rather that 100 mL of distilled water.	
The tip of the burette is not filled with solution before taking the initial reading.	
The top (rather that the bottom) of the meniscus is read at the beginning and end of the titration.	
The actual concentration of the sodium hydroxide solution is less that the value given on the label.	

[5 marks]

END OF PART 2

SEE NEXT PAGE

PART 3 – CALCULATIONS

This part consists of 5 questions worth 48 marks. It is 21% of the paper and should take 45 minutes. Answer ALL questions in Part 3 in the spaces provided using a ball-point pen only. 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. 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.

Question 1

Nickel-cadmium (nicad) alkaline batteries are currently very popular because they maintain a constant potential and are rechargeable. The relevant half-cell reactions for such batteries are given in this table.

Half-Reaction	E°(volts)
$Cd(OH)_2(s) + 2e^- \text{---> } Cd(s) + 2OH^-(aq)$	- 0.809
$NiOOH(s) + H_2O(l) + e^- \text{ ---> } Ni(OH)_2(s) + OH^-(aq)$	+ 0.490

(i) Write a balanced equation for the process that produces electricity in a nicad battery and specify the half-reaction that occurs at the anode.

[4 marks]

(ii) Calculate the potential expected for a nicad battery.

[1 mark]

(iii) If such a battery produces a current of 50 milliamps for a period of 6.00 hours, how many electrons will be transferred?

[3 marks]

(iv) What mass of cadmium will undergo oxidation or reduction during the process in part (c)?

[2 marks]

_____

_____

_____

_____

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Question 2

A sample of impure calcium carbonate weighing 0.2450 g is dissolved in 100 mL of standardized 0.0905 mol L^{-1} hydrochloric acid solution. After the reaction is complete, it is found that the excess acid required 17.0 mL of 0.250 mol L^{-1} sodium hydroxide solution for complete neutralization using phenolphthalein indicator. Find the percentage of calcium carbonate in the sample.

[6 marks]

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Question 3

A textile company uses a solution of sodium hypochlorite to bleach sheets. An industrial chemist employed by the company is asked to investigate the change in the concentration of the bleaching solution after sheets have been soaked in this solution for a time of 2 hours. The original solution is known to contain 30.0 g of sodium hypochlorite per litre of solution.

[The bleaching process slowly reduces hypochlorite ions to chloride ions while at the same time changing double bonds in the sheet fibres into single bonds - an oxidation process]. The chemist removes a sample of the bleaching solution after two hours of bleaching and tests it with sodium thiosulfate solution to determine the final concentration of hypochlorite ions. The redox reaction between hypochlorite ion and thiosulfate ion in an acidified solution may be represented as follows:

$$OCl^-(aq) + 2S_2O_3^{2-}(aq) + 2H^+(aq) \text{ -----> } S_4O_6^{2-}(aq) + Cl^-(aq) + H_2O(l)$$

Using a starch-iodine indicator to moderate the equivalence point of the reaction, it is found that an average of 47.5 mL of 0.250 mol L^{-1} sodium thiosulfate solution is needed to react with 20.0 mL samples of the final bleaching solution.

(i) Calculate the concentration of sodium hypochlorite in mol L^{-1} in the original bleaching solution.

[2 marks]

(ii) Calculate, from the given redox reaction, the concentration of hypochlorite ions in the final bleaching solution.

[8 marks]

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Question 4

An organic compound containing only carbon, hydrogen and nitrogen was analysed as follows:

(a) A sample of the compound of mass 2.435 g was burnt in oxygen gas under such conditions as to convert all the carbon it contained into carbon dioxide gas, and all the hydrogen it contained was converted into water. The masses of carbon dioxide and water were, respectively, 4.753 g and 3.405 g.

(b) When vaporized in the absence of air, a further 2.435 g sample of the compound was found to occupy 1.321 L at 25°C and 101.3 kPa.

(i) From the data in (a), calculate the empirical formula of the compound. [8 marks]

(ii) From the data in (b), calculate the molecular formula of the compound. [4 marks]

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Question 5

In the manufacture of sulfuric acid, liquid sulfur is burned in air to produce sulfur dioxide. The sulfur dioxide is then catalytically converted into sulfur trioxide and then to fuming sulfuric acid, $H_2S_2O_7$, by adding the sulfur trioxide to pure sulfuric acid.

Finally, sulfuric acid is produced by adding a stoichiometric amount of water to the fuming sulfuric acid.

The reactions are:

$$S_8(l) + 8O_2(g) \rightarrow 8SO_2(g)$$
$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$
$$SO_3(g) + H_2SO_4(aq) \rightarrow H_2S_2O_7(aq)$$
$$H_2O(l) + H_2S_2O_7(aq) \rightarrow 2H_2SO_4$$

Assume that each reaction stage proceeds fully to the right and that 100% recovery is made.

(i) Given that the liquid sulfur is 98.0% by mass pure, and that the impurity does not react, find the mass of liquid sulfur needed to produce 1.00 tonne of sulfuric acid. Do not include the sulfuric acid used in the third reaction above. [1 tonne = 10^6 g.]

[4 marks]

(ii) Calculate the volume of oxygen gas measured at 350°C and 98.0 kPa needed to produce the above amount of sulfuric acid.

[4 marks]

(iii) Find the mass of water required in the production of 1.00 tonne of sulfuric acid.

[2 marks]

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END OF PART 3

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PART 4 – EXTENDED ANSWER

This part worth 20 marks. It is 9% of the paper and should take 20 minutes.

Answer ONE of the following essay-type questions using a ball-point pen only. 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 essay, but some marks can also be gained for clarity in arranging a reasonable amount of material in essay form. Your answer should be presented in about 1.5 - 2 pages.

1. Discuss the nature and importance of Van der Waal's (VDW) forces in Chemistry. You should clearly indicate the links between types of VDW forces (ie. hydrogen bonding, dipole-dipole forces and dispersion forces) and the effects they have on **two** physical properties of the molecular substances which have these forces. Give examples.

[20 marks]

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?

[20 marks]

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