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

Standard Items: Pens, pencils, eraser or correction fluid, ruler
Special Items: 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 $Ag^+(aq]$, **molecules** [for example NH_3,(g), $NH_3(aq)$, $CH_3COOH(l)$, $CH_3COOH(aq)$] or **solids** [for example $BaSO_4(s)$, Cu(s), $Na_2CO_3(s)$].

SEE NEXT PAGE

PART 1 (60 marks = 30% of paper)

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

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1. Which formula represents a ketone?

   (a) CH_3OCH_3

   (b) CH_3CH_2COH

   (c) CH_3COCH_3

   (d) $CH_3CH(OH)CH_3$

2. Which formula represents a molecule that can exhibit geometric (*cis/trans*) isomerism?

   (a) $CH_3CHCHCH_3$

   (b) $H_2CCH(CH_3)_2$

   (c) CH_3CCCH_3

   (d) H_2CCHCH_3

3. Which of the following statements about ethene, C_2H_4, are correct?

   I It is a planar molecule.
   II It forms polymers through condensation reactions.
   III It can be converted to an alkane by addition of hydrogen.
   IV It is a saturated molecule.

   (a) I, II and IV only

   (b) II and III only

   (c) I and III only

   (d) I, III and IV only

4 Which of the following pairs of compounds would form methyl propanoate when warmed with sulphuric acid?

   (a) CH_3OH and CH_3COOH

   (b) CH_3OH and $CH_3CH_2CH_2OH$

   (c) $CH_3CH_2CH_2OH$ and HCOOH

   (d) CH_3OH and CH_3CH_2COOH

5 An old bottle of aqueous sodium chloride (molar mass = 58.5) was labelled as 15000 ppm. Which of these would be the correct concentration of this solution in mol L^{-1}?
(assume density of solution = 1.00 gcm^{-3})

(a) 2.57 mol L^{-1}

(b) 0.257 mol L^{-1}

(c) 25.7 mol L^{-1}

(d) 0.0257 molL^{-1}

6. Which of the following pairs of solutions would form a white precipitate when mixed?

(a) sodium nitrate and cobalt chloride

(b) ammonium carbonate and zinc chloride

(c) copper(II) chloride, and potassium hydroxide

(d) iron(II) sulfate and sodium nitrate

7. Which of these atoms is in its ground state configuration?

(a) $1s^2 2s^2 2p^6 3s^2$

(b) $1s^2 2s^2 2p^6 3s^2 3p^4 4s^2$

(c) $1s^2 2s^2 2p^6 3p^6 4s^2$

(d) $1s^2 2p^6 3s^2$

8. The first five ionisation energies of an element are as follows:

584 kJ mol^{-1} 1823 kJ mol^{-1} 2751 kJ mol^{-1} 11584 kJ mol^{-1} 14837 kJ mol^{-1}

The element is most likely to be:

(a) Na

(b) Mg

(c) Al

(d) Si

9. A student recorded the following observation in his laboratory notebook:

test	Solution A	Solution C	Observations
4	Colourless solution	Colourless solution	Purple solution formed

This result could have been caused by the unknown solutions having the following identities:

	Solution A	Solution C
(a)	hydrogen peroxide	potassium permanganate
(b)	hydrogen peroxide	manganese(II) chloride
(c)	phenolphthalein	hydrochloric acid
(d)	potassium dichromate	sodium hydroxide

10. The electronegativities of four elements are given below: (they are not represented by their chemical symbols)

W = 2.0 X = 2.1 Y = 3.4 Z = 1.0

Which of the following pairs of atoms are most likely to form molecules that contain polar covalent bonds?

(a) Z and Y

(b) X and X

(c) X and Y

(d) W and X

11. The shape of the molecules formed by the combination of atoms with the electronic configurations:

$1s^2 2s^2 2p^5$ and $1s^2 2s^2 2p^1$

will be:

(a) linear

(b) trigonal pyramidal

(c) bent

(d) trigonal planar

12. The melting points of group VII hydrides is given below

Formula	Melting point(^oC)
HF	
HCl	-114
HBr	-87
HI	-51

The most likely value for the melting point of HF is:

(a) – 140 ^oC

(b) – 90 ^oC

(c) – 170 ^oC

(d) + 170 ^oC

13. In which of the following pairs of substances would the strongest interactions occur between molecules of the solute and the solvent?

	Solute	Solvent
(a)	I_2	C_6H_{12}
(b)	C_8H_{18}	H_2O
(c)	C_2H_5OH	H_2O
(d)	C_8H_{18}	CCl_4

14. Hydrogen is manufactured from natural gas (methane) through the following endothermic reaction:

$$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons 3H_{2(g)} + CO_{(g)}$$

Which of the following statements about this process is false?

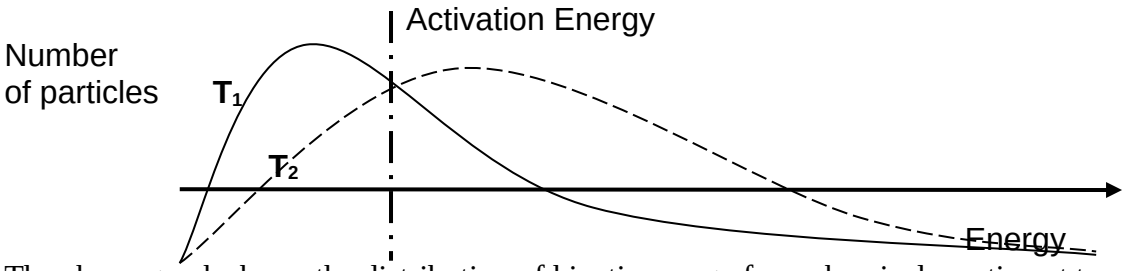
(a) Increasing the temperature will increase the rate of the forward reaction

(b) Increasing the pressure will mean that the equilibrium yield of hydrogen increases.

(c) Removing carbon monoxide will encourage the formation of hydrogen.

(d) Using a catalyst may speed up the forward reaction.

15.



The above graph shows the distribution of kinetic energy for a chemical reaction at two different temperatures, T_1 and T_2.
Which of the following statements about the graph is **false**?

(a) T_2 is higher than T_1

(b) The area under the graph to the right of the activation energy line is related to the rate of the reaction.

(c) The use of a catalyst will have more effect on the reaction carried out at T_2 than if it were occurring at T_1.

(d) This type of graph shows that particles can have a wide range of energies.

16. When sodium hydroxide is added until in excess to a soluble aluminium salt, a white precipitate is formed which then redissolves. The aluminium species goes through the following changes:

(a) $Al^{3+}_{(aq)} \longrightarrow Al(OH)_{3(s)} \longrightarrow [Al(OH)_3]^-_{(aq)}$

(b) $Al^{3+}_{(aq)} \longrightarrow Al(OH)_{3(aq)} \longrightarrow [Al(OH)_4]^+_{(aq)}$

(c) $Al^{3+}_{(aq)} \longrightarrow Al(OH)_{3(s)} \longrightarrow [Al(OH)_4]^-_{(aq)}$

(d) $Al^{3+}_{(aq)} \longrightarrow Al(OH)_{3(aq)} \longrightarrow [Al(OH)_4]^-_{(aq)}$

17. A sample of sulphuric acid was found to have a pH of 1.00. What would be the concentration of SO_4^{2-} ions assuming total dissociation of the acid?

(a) 0.050 mol L^{-1}

(b) 0.10 mol L^{-1}

(c) 0.50 mol L^{-1}

(d) 0.2 mol L^{-1}

18. In the titration of hydrochloric acid and sodium hydroxide, which would be the correct liquids used to rinse the relevant glassware used in the titration, **before** the start of the experiment?

Conical flask	Burette	Pipette

(a)	distilled water	hydrochloric acid	sodium hydroxide
(b)	sodium hydroxide	hydrochloric acid	distilled water
(c)	distilled water	sodium hydroxide	distilled water
(d)	hydrochloric acid	distilled water	sodium hydroxide

19. The following question relates to this process:

$$[Fe(H_2O)_6]^{+++}_{(aq)} \rightleftharpoons H^+_{(aq)} + [Fe(OH)(H_2O)_5]^{++}_{(aq)}$$

Which of the following statements is false?

(a) The $[Fe(OH)(H_2O)_5]^{++}_{(aq)}$ is acting as a base.

(b) Iron(III) salts will form acidic solutions

(c) Reducing the pH would favour the forward reaction.

(d) $[Fe(H_2O)_6]^{+++}$ is the conjugate acid of $[Fe(OH)(H_2O)_5]^{++}$

20. A mixture of $SO_{2(g)}$ and $O_{2(g)}$ at a fixed temperature reacts according to the equation:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$$

Which of the following gives the correct expression for the equilibrium constant for this reaction?

(a) $\dfrac{[SO^3]}{[SO_2]\,[O_2]}$

(b) $\dfrac{[SO^3]^2}{[SO_2]\,[O_2]}$

(c) $\dfrac{[SO^3]^{2-}}{[O_2]\,[SO_2]^2}$

(d) $\dfrac{[SO^3]}{[SO_2]\,[O_2]^2}$

21. Which one of the following solutions could not be used to convert sodium iodide to iodine?

(a) $Br_{2(aq)}$

(b) $KMnO_{4(aq)}$

(c) $HClO_{(aq)}$

(d) $FeBr_{2(aq)}$

22. In which of the following species does sulphur have the highest oxidation number?

(a) H_2SO_4

(b) SO_3^{2-}

(c) $K_2S_2O_3$

(d) H_2S

23. During the purification of copper, how many moles of electrons would have to be passed through a solution of $CuSO_4$ for the circuit to deposit 318g of pure copper?

(a) 5

(b) 10

(c) 20

(d) 2.5

24. Which of the following statements concerning the Brønsted theory of acids and bases is false?

(a) In aqueous solutions, bases are those cations, anions or molecules that donate protons to other species.

(b) The ability to accept protons from other species in aqueous solution is a property of bases.

(c) A base is produced when a cation, anion or molecule donates a proton in aqueous solution.

(d) When a proton is donated by one species to another in aqueous solution, the reaction is classified as acid-base.

25. Which one of the following correctly arranges 1.0 mol L^{-1} solutions of the substances in the order of increasing pH?

(a) HNO_3 H_2SO_4 CH_3COOH CH_3COONa

(b) H_2SO_4 HNO_3 CH_3COOH CH_3COONa

(c) HNO_3 CH_3COONa H_2SO_4 CH_3COOH

(d) CH_3COOH CH_3COONa HNO_3 H_2SO_4

26. What volume of 0.400 mol L^{-1} NaOH is needed to completely neutralise 100.0 mL of 0.200 mol L^{-1} HCl ?

(a) 5.0 mL.

(b) 35.0 mL.

(c) 50.0 mL.

(d) 100.0 mL.

27. Sodium hydroxide is unsuitable for use as a primary standard reagent in volumetric analysis because:

(a) it is difficult detecting the end point using sodium hydroxide.

(b) solid sodium hydroxide absorbs moisture and carbon dioxide from the air.

(c) strong bases are not suitable for volumetric analysis.

(d) there are no suitable indicators for the pH range of sodium hydroxide.

28. Pieces of magnesium metal can be connected to an iron pipe to prevent the corrosion of the iron.

The best explanation for this fact is that:

(a) the magnesium forms a protective coating $Mg(OH)_2$ on the iron.

(b) the magnesium goes into solution, and the electrons released flow to the iron and prevent its corrosion.

(c) magnesium atoms fill the vacancies in the iron crystals left by the iron atoms lost during corrosion.

(d) a protective coating of Fe^{3+} is left on the iron as electrons flow from the iron to the magnesium.

.

29. The equation for the formation of ammonia gas during the Haber process is shown below:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons^{\text{Fe catalyst}} 2NH_{3(g)} + \text{HEAT}$$

The reaction conditions are 450°C and 100 atmospheres pressure.

Which of the following statements is true?

(a) The equilibrium amount of $NH_{3(g)}$ is increased as the temperature is further increased.

(b) The equilibrium amount of $NH_{3(g)}$ is increased as the pressure is further increased.

(c) The equilibrium amount of $NH_{3(g)}$ is increased as additional Fe is added.

(d) The rate of the reaction is decreased as the temperature is further increased.

30. The overall reaction occurring in a dry cell can be represented as:

$$Zn_{(s)} + 2NH_4^{+}{}_{(aq)} + 2MnO_{2(s)} \longrightarrow Zn^{2+}{}_{(aq)} + Mn_2O_{3(s)} + H_2O_{(l)} + 2NH_{3(aq)}$$

Which of the following statements regarding this process are correct?

I The zinc is reduced.
II The NH_4^+ ion acts as a source of protons.
III The manganese is reduced.
IV Oxygen is reduced.

(a) **I**, **II** and **III** only

(b) **II**, **III** and **IV** only

(c) **II** and **III** only

(d) **I** and **III** only

END OF PART 1

PART 2 (70 marks = 35% 0f 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) Chromium (III) nitrate solution is added to sodium carbonate solution

Equation _____

Observation _____

_____

[3 marks]

(b) Solid chromium (III) hydroxide is added to 6 mol L^{-1} sodium hydroxide and heated.

Equation _____

Observation _____

_____

[3 marks]

(c) Potassium dichromate solution is added to sodium hydroxide solution.

Equation _____

Observation _____

_____

[3 marks]

(d) Potassium dichromate is added to ethanol in the presence of acid and warmed.

Equation _____

Observation _____

_____

[3 marks]

2. Complete the table below by choosing two substances from the following list that match the description. (You can use each substance more than once)

ethanoic acid	ammonium nitrate
1,2-dichloro-1-pentene	sodium hydroxide

2-butene
1,1,2-trichloropropene
ammonia
aluminum hydroxide
iron (II) hydroxide
iodine

Description	Names	
Form weakly acidic solutions in water.		
Show geometric (*cis/trans*) isomerism.		
Are coloured.		
Are involved in the processing of bauxite.		
Form hydrogen bonds.		
Have a total of 9 atoms in their formula.		

[12 marks]

3. Calculate the pH of the following solutions. (Assume total dissociation has occurred)

(a) 0.010 mol L^{-1} sulphuric acid.

(b) 2.0 mol L^{-1} sodium hydroxide

[3 marks]

4. This question relates to the following reaction:

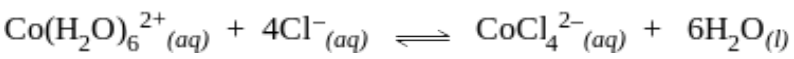
$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)} \qquad \Delta H = +180 \text{ kJ mol}^{-1}$$

Complete the table by predicting and explaining the effect on the position of equilibrium of the following imposed changes. (simply stating Le Chateliers principle does not constitute an explanation)

Imposed change	**Affect on equilibrium position** to right, to left, or no change	**Explanation**
Increased Temperature		
Reduce the volume of the reaction vessel		
Remove some of the NO(g)		

[6 marks]

5. Write the equilibrium constant expression for the following reaction.



[2 marks]

6. Potassium permanganate solution was added to a solution of potassium bromide. On addition of a few drops of dilute sulfuric acid the purple colour of the permanganate started to fade. When carbon tetrachloride, an organic solvent was added, the organic layer showed an orange colouration caused by bromine.

(a) Write the equations for the redox reactions occurring.

Oxidation half-equation:
Reduction half-equation:
Overall equation:

[3 marks]

(b) Explain why the addition of the sulfuric acid was necessary.

_____

_____

_____

[1 marks]

(c) Using the concepts of intermolecular bonding, explain why the product, bromine is more soluble in the organic solvent than in water.

_____

_____

_____

_____

_____

_____

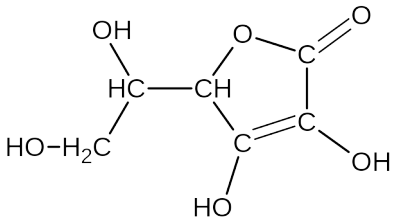
_____

_____

_____

[3 marks]

7. The structure of Vitamin C (ascorbic acid) is shown below. It is needed for the formation of tissues, teeth and bone but is easily oxidised, which is why boiling food containing Vitamin C reduces their positive effect on our health.



(a) Name two functional groups present in a molecule of ascorbic acid and circle them on the diagram.

_____ _____

[3 marks]

(b) Explain why ascorbic acid is easily oxidised.

_____

_____

_____

_____

_____

[2 marks]

8. For each species listed in the table below draw an electron dot diagram to show the bonding, indicate the shape, and state the polarity of the species.

Species	Electron dot diagram (show all valence electrons)	Shape (sketch or name)	Polarity (polar or non-polar)
Cl_2O			
ClO_3^-			

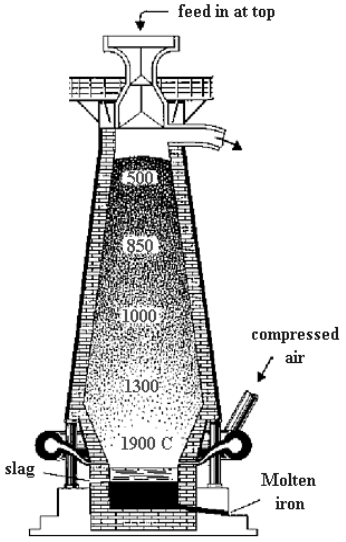
[6 marks]

9. Complete the following table by drawing and naming 3 isomers of the compound with molecular formula C_4H_8O that match the descriptions.

Description	Structure	IUPAC Name
Can be oxidised to form a carboxylic acid.		
Can be produced by reacting 2-butanol with acidified potassium dichromate.		
Is a saturated alcohol.		

[6 marks]

10. The overall equation for the production of iron in a blast furnace is as follows:



$$Fe_2O_{3(s)} + 3CO_{(g)} \rightleftharpoons 2Fe_{(l)} + 3\ CO_{2(g)}$$

Slag ($CaSiO_3$) and molten iron are removed from the bottom of the furnace.

The molten iron can be converted directly into alloy steels by adding other metals.

(a) By means of an equation show how the carbon monoxide is formed in the blast furnace.

_____

[1 mark]

(b) Name the two compounds that combine to form slag.

_____ _____

[1 mark]

(c) Name the two metals added to the iron to make stainless steel

_____ _____

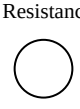
[1 mark]

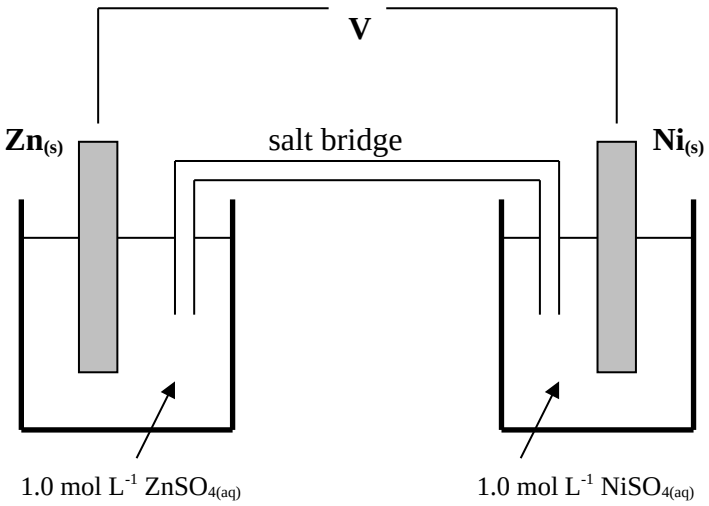
(d) Suggest how the addition of the these metals will affect the chemical properties of the iron.

_____

[1 mark]

11. The following diagram shows a cell set up to investigate the redox behaviour of zinc and nickel.





(a) Using the Standard Reduction Potentials on the data sheet, calculate the overall electrode potential of this cell.

[2 marks]

(b) On the above diagram show the direction of flow of electrons in the external circuit.

[1 mark]

(c) What would be observed when solid zinc is added to a solution of $Ni(NO_3)_{2\,(aq)}$?

_____

_____

[2 marks]

(d) Explain your answer to part (c)

_____

_____

_____

[2 marks]

END OF PART 2

PART 3 (50 marks = 25% of the 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.

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1. A portable gas heater like the one illustrated runs from
either: A) butane gas cylinders,
or: B) from a household supply of natural gas(methane).

The equation for the complete combustion of butane is as follows:

$$2C_4H_{10(g)} + 13O_{2(g)} \longrightarrow 8CO_{2(g)} + 10H_2O_{(g)}$$

In normal use, one cylinder that contains 500g of butane will give 150 hours of use.

The methane from the mains is normally supplied at 200 kPa pressure at a rate of 2.40 L per hour.

Assume a temperature of 20°C throughout.

(a) Which mode of operation requires the most oxygen per hour to sustain complete combustion of the butane during normal operation? (show all working)

[6 marks]

(b) Calculate the volume of carbon dioxide, at 20°C and 1 atm pressure produced during 10 hours of normal operation when running on the butane cylinders.

[2 marks]

(c) Calculate the mass of water produced during 10 hours of normal operation when running on the butane cylinders.

[2 marks]

2. Sulfur dioxide (SO_2) is an effective and safe preservative, antioxidant, and antimicrobial agent that has been used for millennia to facilitate the winemaking process. Usual levels of free sulfur dioxide in table wines are about 20 to 40 mg/L. (1 g = 1000 mg)

SO_2 is commonly sourced from sodium metabisulphite tablets, known as Campden tablets which have a mass of 0.440 g.

Free SO_2 is measured in milligrams per litres, or mg/L, which is equivalent to 1 ppm.

The equation for the conversion of sodium metabisulphite to free SO_2 is as follows:

$$Na_2S_2O_{5(s)} + 2H^+_{(aq)} \rightleftharpoons 2SO_{2(aq)} + H_2O_{(aq)} + 2Na^+_{(aq)}$$

sodium metabisulphite

The following information was provided to the winemaker:

pH of wine	3.20
Original level of free SO_2 in wine	0 mg/L
Final level of free SO_2 required	20 mg/L
Volume of wine to be corrected	100 Litres
Number of Campden tablets required	8

(a) Calculate the total number of moles of sodium metabisulphite in the 8 tablets.

[3 marks]

(b) Calculate the number of moles of sulfur dioxide that would be produced from these tablets assuming 100% efficiency of the above reaction.

[1 marks]

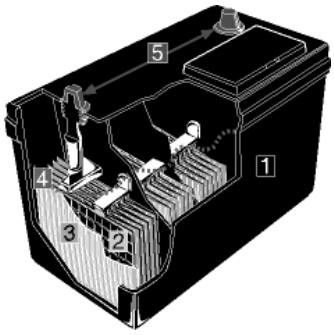
(c) From the above results table, calculate the actual number of moles of sulfur dioxide added to the wine and hence work out the actual % efficiency of the conversion of metabisulphite to free SO_2.

[4 marks]

(d) Explain how increasing the pH of the wine will affect this efficiency.

[2 marks]

3. The reactions occurring in a car battery as it is being discharged are as follows:



Anode:

$$Pb_{(s)} + SO_4^{2-}{}_{(aq)} \longrightarrow PbSO_{4(s)} + 2e^-$$

Cathode:

$$PbO_{2(s)} + 4H^+_{(aq)} + SO_4^{2-}{}_{(aq)} + 2e^- \longrightarrow PbSO_{4(s)} + 2H_2O_{(l)}$$

Overall Reaction:

$$PbO_{2(s)} + Pb_{(s)} + 2H_2SO_{4(aq)} \longrightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$$

A fully charged battery contains 1.08 L of sulfuric acid, which is made up from 370g of H^2SO^4 and 890g of H^2O.

The level of charge in a battery is measured using a hydrometer which records the overall density of the sulfuric acid and if this drops below 1.11 g/cm^3 the car will not start. This is equivalent to a 22% composition by mass

% Composition by mass = (mass of solute/mass of solution) x 100

An overworked chemistry teacher parked his car early one morning and returned later to find that the headlights had been left on for 4 hours. The lights had been drawing a total of 10 amps throughout this time. (The battery was fully charged at the start of the 4 hours)

(a) Calculate the concentration of the original battery acid as % composition by mass.

[1 marks]

(b) Calculate the amount of charge and hence the number of moles of electrons that would have been discharged by the headlights in the 4 hours.

[2 marks]

(c) Calculate the mass of sulfuric acid used up, and mass of water produced during the 4 hours that lights were left on.

[3 marks]

(d) Calculate the concentration of the battery acid (as % by mass) after the 4 hours. and hence deduce whether the car will start.

[2 marks]

(e) If 100mL of acid from a fully charged battery was spilled, what would be the minimum volume of 2.00 mol L^{-1} NaOH required to neutralise the spillage?

[4 marks]

_____

_____

_____

4. A hydrated iron salt had the following formula:

$Fe^{x}(SO^{4})^{y}.zH^{2}O$

A 24.0 g sample of the hydrated form of the salt was heated to dryness and the resulting solid had a mass of 21.2 g.

This 21.2 g of the anhydrous salt was dissolved in 250mL of water. 25.0 mL of this solution produced 3.58 g of solid barium sulfate when treated with excess aqueous barium nitrate.

(a) Calculate the values of *x*, *y* and *z* and hence give the formula of the hydrated form of the unknown salt.

[7 marks]

(b) Calculate the mass of iron that could be produced from 5.00g from the hydrated salt through a reduction process that was 75% efficient.

[3 marks]

5. An experiment was carried out to determine the amount of active chlorine in a sample of household bleach. The chlorine is present in the form of sodium hypochlorite (NaClO).

The hypochlorite is reacted with aqueous potassium iodide to liberate iodine:

$$ClO^-_{(aq)} + 2I^-_{(aq)} + 2\,H^+_{(aq)} \longrightarrow I_{2(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$$

The iodine produced is then titrated against sodium thiosulphate ($Na_2S_2O_3$):

$$I_{2(aq)} + 2S_2O_3^{2-}{}_{(aq)} \longrightarrow 2I^-_{(aq)} + S_4O_6^{2-}{}_{(aq)}$$

5.0 mL of the bleach solution was added to 250 mL volumetric flask. Approximately 25 mL of 0.5 mol L^{-1} potassium iodide was added, along with approximately 25 mL of 2 mol L^{-1} sulphuric acid. The flask was filled to 250 mL with distilled water.

25.0 mL of the resulting solution was titrated against 0.100 mol L^{-1} sodium thiosulphate and required 15.5 mL of this solution to remove all the iodine produced.

(a) Calculate the amount (in mole) of thiosulphate needed to react with the liberated iodine in the titration flask.

[2 marks]

(b) Calculate the amount (in mole) of iodine in the titration flask and hence the amount of hypochlorite that liberated this iodine.

[2 marks]

(c) Calculate the amount (in mole) of hypochlorite in the 250 mL volumetric flask.

[1 marks]

(d) Calculate the concentration of sodium hypochlorite ions in the original bleach in:

(i) mol L^{-1}

(ii) g L^{-1}.

[3 marks]

END OF PART 3

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 principally for the relevant chemical content of your answer, and also for coherence and clarity of expression. Your answer should be presented in about 1½ to 2 pages on the lined paper after the questions.

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1. Below is a summary of two techniques for measuring alcohol in exhaled air.

Breathalyser

To measure alcohol, a suspect breathes into the device. The breath sample is bubbled into a tube containing mixture of sulfuric acid, potassium dichromate, silver nitrate and water. The principle of the measurement is based on the following chemical reaction:

$$2K_2Cr_2O_7 + 3CH_3CH_2OH + 8H_2SO_4 \xrightarrow{\text{silver nitrate}} 2\,Cr_2(SO_4)_3 + 2K_2SO_4 + 11H_2O + 3CH_3COOH$$

The degree of the colour change is directly related to the level of alcohol in the expelled air. The reacted mixture is compared to a tube of unreacted mixture in a photocell system, which produces an electric current.

The greater the current, the greater the level of alcohol.

Fuel-cell Detectors

The fuel cell has two platinum electrodes with a porous acid-electrolyte material sandwiched between them. As the exhaled air from the suspect flows past one side of the fuel cell, the platinum oxidises any alcohol in the air to produce ethanoic acid, H^+ ions and electrons.

The electrons flow through a wire from the platinum electrode. The hydrogen ions move through the lower portion of the fuel cell and combine with oxygen and the electrons on the other side to form water.

The more alcohol that becomes oxidised, the greater the electrical current.

Discuss in detail the oxidation and reduction processes occurring in the two analysis techniques and the role of all the reagents used. Include half equations, identifying anode and cathode reactions as necessary, and observations and diagrams where appropriate. Explain any differences and similarities between the two techniques.

SEE OVER FOR QUESTION 2

OR

2. The pH of a solution is defined as:

$$pH = -\log[H^+_{(aq)}] \qquad \text{where} \quad [H^+_{(aq)}]\,[OH^-_{(aq)}] = 10^{-14}$$

The pH of a variety of aqueous solutions were measured at 25°C using a pH meter and the results given below in table A:

Table A

Test	Solution	pH
1	0.1 mol L^{-1} HCl	1.0
2	0.1 mol L^{-1} HNO_3	1.0
3	0.1 mol L^{-1} H_2SO_4	0.6
4	0.1 mol L^{-1} HI	4.2
5	0.1 mol L^{-1} CH_3COOH	3.7
6	0.1 mol L^{-1} CHOOH	2.9

The pH meter was then used to record the pH of some combinations of solutions:

Table B

Test	Solutions	pH
1	20 mL of 0.1 mol L^{-1} HCl + 20 mL of 0.1 mol L^{-1} NaOH	7.0
2	20 mL of 0.1 mol L^{-1} HCl + 20 mL of 0.1 mol L^{-1} NH_4OH	4.0
3	20 mL of 0.1 mol L^{-1} CH_3COOH + 20 mL of 0.1 mol L^{-1} NaOH	9.0
4	20 mL of 0.1 mol L^{-1} HCl + 19 mL of 0.1 mol L^{-1} NaOH	2.6

Using the concepts of acid-base equilibrium, explain in detail the chemistry behind the variation in pH values within each of the two tables. No calculations are required but equations should be used whenever possible.

END OF QUESTIONS

END OF EXAM

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