1991

CHEMISTRY

YEAR 12

TRIAL EXAM

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CANDIDATE'S NAME_____

CHEMISTRY ASSOCIATES

YEAR 12 CHEMISTRY TRIAL EXAMINATION 1991
(not to be used before Thursday August 1, 1991)
Time allowed for examination = 3 hours.

MULTIPLE CHOICE ANSWER SHEET SECTION A

Instructions:(1) Mark letters with a single pencil line
EXAMPLE A B ~~C~~ D
(2) Completely erase any mistakes.
(3) One and only one letter should be marked for each item

(1)	A	B	C	D
(2)	A	B	C	D
(3)	A	B	C	D
(4)	A	B	C	D
(5)	A	B	C	D
(6)	A	B	C	D
(7)	A	B	C	D
(8)	A	B	C	D
(9)	A	B	C	D
(10)	A	B	C	D
(11)	A	B	C	D
(12)	A	B	C	D
(13)	A	B	C	D
(14)	A	B	C	D
(15)	A	B	C	D
(16)	A	B	C	D
(17)	A	B	C	D
(18)	A	B	C	D
(19)	A	B	C	D
(20)	A	B	C	D
(21)	A	B	C	D
(22)	A	B	C	D
(23)	A	B	C	D
(24)	A	B	C	D
(25)	A	B	C	D
(26)	A	B	C	D
(27)	A	B	C	D
(28)	A	B	C	D
(29)	A	B	C	D
(30)	A	B	C	D
(31)	A	B	C	D
(32)	A	B	C	D
(33)	A	B	C	D
(34)	A	B	C	D
(35)	A	B	C	D
(36)	A	B	C	D
(37)	A	B	C	D

DETACH THIS ANSWER SHEET AT THE START OF THE EXAMINATION

CHEMISTRY ASSOCIATES CANDIDATE'S NAME _____

YEAR 12 CHEMISTRY TRIAL EXAMINATION 1991

Time allowed for examination = 3 hours

Structure of examination paper: Number of booklets = 1
Number of Sections = 2

SECTION	NUMBER OF QUESTIONS	NUMBER OF QUESTIONS TO BE ANSWERED	PERCENTAGE OF EXAMINATION
A	1 (37 items)	1 (37 items)	33
B	9 (numbered 2 to 10)	9 (numbered 2 to 10)	67

There is a Multiple Choice Answer Sheet attached to the front of this booklet.

DIRECTIONS TO CANDIDATES

(1) Answer ALL questions.

(2) Section A questions must be answered on the Multiple Choice Answer Sheet provided.

(3) Section B questions must be answered in the spaces provided.

(4) Approved calculators may be used.

(5) To answer certain questions, you may need to refer to the data sheet on the back of this page.

(6) At the end of the examination, place the Multiple Choice Answer Sheet inside the back cover of this booklet and hand them in.

(7) Please ensure that you write your name on this booklet AND on the Multiple Choice Answer Sheet.

SPECIFIC INSTRUCTIONS FOR SECTION A

(1) Section A, Question 1, consists of 37 multiple choice items and is worth 37 marks and therefore about 33% of the total marks available for this examination.You should therefore spend about 60 minutes on Section A.

(2) Choose the response you consider is correct or best, and mark your choice on the Multiple Choice Answer Sheet according to the instructions on that sheet.

(3) A correctly answered item scores 1, an incorrect item scores 0. No credit will be given for an item if two or more letters are marked for that item. Marks will NOT be deducted for incorrect answers and you are urged to attempt every item.

(4) Jottings should be done in the WORKING SPACES in this booklet.

DATA

TABLE 1: RELATIVE ATOMIC MASS ($^{12}C = 12.00$)

Element	Symbol	Atomic No.	Relative Atomic Mass
Silver	Ag	47	107.9
Aluminium	Al	13	27.0
Barium	Ba	56	137.3
Bromine	Br	35	79.9
Calcium	Ca	20	40.1
Carbon	C	6	12.0
Chlorine	Cl	17	35.5
Copper	Cu	29	63.5
Iron	Fe	26	55.9
Hydrogen	H	1	1.0
Magnesium	Mg	12	24.3
Nitrogen	N	7	14.0
Sodium	Na	11	23.0
Oxygen	O	8	16.0
Phosphorus	P	15	31.0
Sulfur	S	16	32.1
Strontium	Sr	38	87.6
Zinc	Zn	30	65.4

TABLE 2: E^{o} values at 298 K

Half reaction	E^{o}/V
$Ag^{+}(aq) + e^{-} = Ag(s)$	+0.80
$Al^{3+}(aq) + 3e^{-} = Al(s)$	-1.67
$Cu^{2+}(aq) + 2e^{-} = Cu(s)$	+0.35
$2H^{+}(aq) + 2e^{-} = H_2(g)$	0.00
$Na^{+}(aq) + e^{-} = Na(s)$	-2.71
$PbO_2(s) + SO_4^{2-}(aq) + 4H^{+}(aq) + 2e^{-} = PbSO_4(s) + 2H_2O(l)$ . . .	+1.69
$PbSO_4(s) + 2e^{-} = Pb(s) + SO_4^{2-}(aq)$	-0.36
$Zn^{2+}(aq) + 2e^{-} = Zn(s)$	-0.76

TABLE 3: PHYSICAL CONSTANTS

Avogadro Constant (N_A)	6.023×10^{23} mol^{-1}
Faraday Constant (F)	96 500 C mol^{-1}
Gas Constant (R)	8.31 J K^{-1} mol^{-1}
Molar Volume of gas at STP	22 400 cm^3 mol^{-1} = 22.4 dm^3 mol^{-1}
Pressure	1 atmosphere = 101 325 Pa

Item 1
An ion formed by aluminium will have
A. the same number of protons and electrons.
B. more protons than electrons.
C. the same number of protons and neutrons.
D. more electrons than protons.

Item 2
The combustion of the hydrocarbon octane, C_8H_{18}, is given by the equation:

$$2C_8H_{18}(l) + 25O_2(g) = 16CO_2(g) + 18H_2O(g) \; ; \quad \Delta H = -10{,}900 \text{ kJ mol}^{-1}$$

When 1 mole of octane is burnt with excess oxygen, the energy released would be
A. 2725 kJ
B. 5450 kJ.
C. 10,900 kJ.
D. 21,800 kJ.

Item 3
According to the theory of nucleogenesis, all of the elements of lower mass than iron were formed
A. during the gravitational collapse of a hydrogen gas cloud.
B. at the same time as the element helium.
C. during a supernova explosion.
D. immediately after the formation of iron.

Item 4
Which one of the following statements is correct?
Group I metals
A. have high melting temperatures.
B. form white oxides.
C. are magnetic.
D. show more than one oxidation state.

Item 5
The element which contains the largest number of neutrons is
A. iron
B. hydrogen
C. silicon
D. helium

Item 6
Ethyl benzene can be produced by the action of chloroethane on benzene in the presence of a catalyst such as aluminium chloride. The molecular formula of ethyl benzene is
A. C_7H_{10}
B. C_7H_{11}
C. C_8H_{10}
D. C_8H_{11}

Item 7
Of the following, the compound with the LARGEST percentage by mass of nitrogen is
A. NH_4NO_3
B. $(NH_4)_2SO_4$
C. NH_3
D. HNO_3

Item 8
When 5 cm^3 of 0.01M hydrochloric acid is mixed with 15 cm^3 of 0.03M hydrochloric acid, the hydrogen ion concentration of the resulting solution is
A. 0.045 M
B. 0.035 M
C. 0.025 M
D. 0.015 M

Item 9
In the partial ionic equation, $2CrO_4^{2-} + 10H^+ + 6e^- = Cr_2O_3 + 5H_2O$,
the change in the oxidation number of the element chromium is
A. +8 to +3
B. +6 to +2
C. +12 to +6
D. +6 to +3

Item 10
In the partial ionic equation,

$$2MnO_2(s) + 2NH_4^+(aq) + 2e^- = Mn_2O_3(s) + 2NH_3(aq) + H_2O(l)$$

the element which is changing its oxidation number is
A. hydrogen
B. oxygen
C. nitrogen
D. manganese

Item 11

Potassium dichromate, $K_2Cr_2O_7$, can be used to oxidise ethanol to acetic acid according to the partial equations: $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$ and

$$C_2H_5OH(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + 4H^+(aq) + 4e^-$$

The volume of 0.1M potassium dichromate required to oxidise 9.2 g of ethanol to acetic acid is

A. 0.33 dm^3.
B. 1.33 dm^3.
C. 2.33 dm^3.
D. 4.33 dm^3.

Item 12

An element consists of two naturally occurring isotopes, one of which has a percentage abundance of 67.00% and a relative isotopic mass of 40.50. The relative isotopic mass of the other isotope is 39.00. The relative atomic mass of the element is

A. 39.25
B. 39.50
C. 40.00
D. 40.25

Item 13

Nitric acid can be manufactured from the element nitrogen using the steps:

1 **2** **3** **4**

$N_2 \text{-------} \rightarrow NH_3 \text{-------} \rightarrow NO \text{-------} \rightarrow NO_2 \text{-------} \rightarrow HNO_3$

The step in which there is a change of -1 in the oxidation number of nitrogen is

A. **1**
B. **2**
C. **3**
D. **4**

Item 14

Which one of the following gases will react with potassium hydroxide, KOH?

A. oxygen
B. hydrogen
C. carbon dioxide
D. nitrogen

Item 15

In a fuel cell, the reactions occurring in acid solution are: $2H^+(aq) + 2e^- \rightarrow H_2(g)$ and $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$. If the voltage of the cell is 1.23V, calculate the energy output of the cell when 10 g of hydrogen gas is consumed.

A. 1.23 x 10 x 96 500 J
B. 1.23 x 5 x 96 500 J
C. $1.23 \times \frac{10}{96\,500}$ J
D. $1.23 \times \frac{5}{96\,500}$

Item 16

Which one of the following does **not** make use of limestone in its manufacture?
A. cement
B. glass
C. sodium carbonate
D. aluminium

Item 17

The empirical formula of methyl benzene is
A. C_7H_9
B. C_6H_8
C. C_7H_8
D. C_6H_9

Items 18 and 19 refer to the following information.

Carbon dioxide is involved in a large number of reactions in the biosphere. Some of these reactions are shown by the equations below in which the letters A, B, D and E stand for specific chemical compounds or elements.

(1) carbon dioxide + A $\rightarrow$ B + oxygen
(2) carbon dioxide + A $\rightarrow$ D
(3) D + A $\rightarrow$ hydronium ion + hydrogen carbonate ion
(4) B $\rightarrow$ E + carbon dioxide

Item 18

Compounds A and B are respectively
A. water and glucose.
B. water and carbonic acid.
C. carbon (graphite) and carbon monoxide.
D. carbon (graphite) and carbon (diamond).

Item 19
Compounds D and E are respectively
A. glucose and ethanol.
B. glucose and acetic acid.
C. carbonic acid and ethanol.
D. carbonic acid and acetic acid.

Item 20
The most likely formula for the amino acid alanine in a 1M HCl solution is
A. $^{+}NH_3CH_2COO^{-}$
B. $^{+}NH_3CHCH_3COO^{-}$
C. $^{+}NH_3CHCH_3COOH$
D. $^{+}NH_3CH_2COOH$

Items 21 and 22 refer to the fxollowing information.
When concentrated aqueous ammonia is added to a precipitate of copper(II) hydroxide, the precipitate dissolves to give a deep blue solution according to the equation:
$Cu^{2+}(aq) + 4NH_3(aq) \Leftrightarrow Cu(NH_3)_4^{2+}(aq)$

Item 21
The bonding in the complex ion, $Cu(NH_3)_4^{2+}(aq)$, is mainly
A. covalent bonding and hydrogen bonding.
B. ion-dipole bonding and covalent bonding.
C. metallic bonding and hydrogen bonding.
D. metallic bonding and ion-dipole bonding.

Item 22
The addition of the ammonia causes the copper(II) hydroxide to dissolve because
A. $Cu^{2+}(aq)$ is removed from the equilibrium: $Cu(OH)_2(s) \Leftrightarrow Cu^{2+}(aq) + 2OH^{-}(aq)$.
B. NH_4OH is produced by reaction of NH_3 with H_2O.
C. copper(II) hydroxide is more soluble in solutions of high pH.
D. strong hydrogen bonds are formed between the ammonia and the copper(II) hydroxide.

Item 23
Which one of the following lists contains a **neutral** oxide?
A. CO_2 , NO_2 , SO_2
B. Al_2O_3 , P_4O_{10} , SO_3
C. CO_2 , NO , SO_3
D. SiO_2 , Na_2O , SO_2

Item 24

The chemical reactions that are **typical** of the compounds methane, ethene (ethylene) and benzene are known respectively as

A. substitution, substitution, addition.
B. substitution, addition, substitution.
C. addition, substitution, substitution.
D. addition, addition, substitution.

Item 25

Which one of the following statements about structural isomers is true? Structural isomers

A. have the same empirical formula but different molecular formulae.
B. have the same structural formula but different molecular formulae.
C. have the same molecular formula but different empirical formulae.
D. have the same molecular formula but different structural formulae.

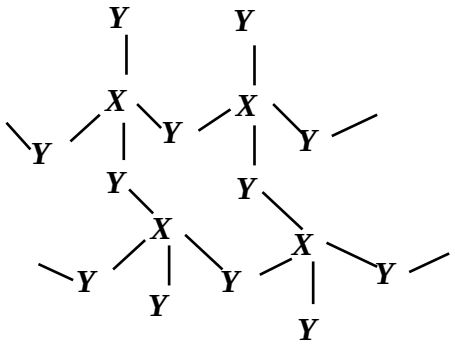
Item 26

The molecules benzene and ethene (ethylene) are structurally similar because both molecules

A. contain double and single covalent bonds.
B. are planar.
C. have tetrahedral bond arrangements.
D. contain carbon and hydrogen atoms in a ratio of 1 : 1.

Item 27

A certain substance has the covalent lattice structure illustrated below where ***X*** and ***Y*** are different atoms.



Which one of the following is best represented by this structure?

A. diamond
B. silicon carbide
C. silicon dioxide
D. carbon dioxide

Item 28

Silane and methane react with oxygen according to the equations:

$SiH_4(g) + 2O_2(g) \rightarrow SiO_2(s) + 2H_2O(l)$ . . . (1)

$CO_2(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ . . . (2)

Which one of the following statements about these reactions is true? Both reactions are

A. exothermic and (1) occurs more readily than (2).
B. exothermic and (2) occurs more readily than (1).
C. endothermic and (1) occurs more readily than (2).
D. endothermic and (2) occurs more readily than (1).

Item 29

When glucose molecules polymerise to form starch

A. an addition reaction occurs and the product is $(C_6H_{12}O_6)_n$.
B. an addition reaction occurs and the product is $(C_6H_{10}O_5)_n$.
C. a condensation reaction occurs and the product is $(C_6H_{12}O_6)_n$.
D. a condensation reaction occurs and the product is $(C_6H_{10}O_5)_n$.

Item 30

In the helical structure of DNA, the nitrogen bases that are joined together by hydrogen bonding are respectively

A. adenine with guanine and thymine with cytosine.
B. adenine with cytosine and guanine with thymine.
C. adenine with adenine and thymine with cytosine.
D. adenine with thymine and guanine with cytosine.

Item 31

In the Haber Process for the production of ammonia

A. the reaction is endothermic.
B. hydrogen gas is reduced.
C. atmospheric pressure is used.
D. an iron catalyst is used.

Item 32

In the Contact Process for the production of sulfuric acid from elemental sulfur, the oxidation number of sulfur

A. increases by 6.
B. increases by 4.
C. increases by 2.
D. remains unchanged.

Item 33
Nitrogen dioxide may be produced in the laboratory by

A. heating a mixture of nitrogen gas and oxygen gas to $100^{o}C$.
B. adding dilute nitric acid to copper.
C. adding concentrated nitric acid to copper.
D. heating solid ammonium nitrite.

Item 34
Photochemical smog will be produced when nitrogen oxides occur in the presence of
A. carbon monoxide and oxygen.
B. hydrocarbons and sunlight.
C. carbon dioxide and sunlight.
D. sulfur dioxide and oxygen.

Item 35
Ammonia can react with oxygen under controlled conditions to form nitrogen monoxide and water. The mass of nitrogen monoxide that can be produced from 34 g of ammonia in this reaction is
A. 17 g.
B. 30 g.
C. 34 g.
D. 60 g.

Item 36
Sulfur trioxide, SO_3, is absorbed in water to form sulfuric acid, H_2SO_4. Assuming complete ionisation of the sulfuric acid, what is the pH of the resulting solution when 0.5 mol of SO_3 is completely absorbed in 100 cm^3 of water?
A. -log 0.25
B. -log 0.5
C. -log 5
D. -log 10

Item 37
Carbon monoxide, CO, and oxygen, O_2, both react with haemoglobin in the blood according to the equilibria given below.

(1) CO(g) + haemoglobin $\Leftrightarrow$ complex 1 Equilibrium constant = K_1

(2) O_2(g) + haemoglobin $\Leftrightarrow$ complex 2 Equilibrium constant = K_2

Which one of the following statements about these equilibria is true under the same conditions of temperature and pressure?

A. $K_1 < K_2$
B. $K_1 = K_2$
C. $K_1 > K_2$
D. it depends on the concentrations of CO(g) and O_2(g).

END OF SECTION A

SPECIFIC INSTRUCTIONS FOR SECTION B

(1) Section B consists of 9 questions, Questions 2 to 10, and is worth 73 marks and therefore about 67% of the total marks available for the examination. You should therefore spend about 2 hours on Section B. A suggested time allocation is given for each question and the marks allotted to each question are also indicated.

(2) Answers must be written in the spaces following each question in this booklet.

(3) You should show all working in numerical questions. No credit can be given for incorrect answers unless they are accompanied by details of the working.

(4) Full credit will **not** be given for unsimplified answers. When stating an answer, appropriate precision (number of significant figures) must be used and the units included.

(5) When chemical symbols are used in equations they must be accompanied by correct symbols of state, for example $H_2(g)$ for hydrogen gas.

QUESTION 2 (25 minutes, 14 marks)

Sulfuric acid is such an important industrial chemical that it is often claimed that the quantity of sulfuric acid produced in a country is a measure of the economic activity of that country. Briefly describe

(1) the method of production of sulfuric acid.
(2) the properties of sulfuric acid.
(3) the uses of sulfuric acid.

(An essay is **NOT** required. The information may be provided in point form. Credit will be given for all relevant factual information.)

QUESTION 2 (continued)

QUESTION 3 (25 minutes, 14 marks)

Metallic iron can be produced in a spectacular exothermic reaction by mixing aluminium powder with finely divided iron(III) oxide and igniting the mixture using a magnesium fuse. The reaction is called the **thermite** reaction. The heat of reaction is sufficient to produce iron in molten form. The other product in the reaction is aluminium oxide.

(a) Write a balanced equation for the thermite reaction.

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(b) In such a reaction, 10 g of iron(III) oxide was mixed with 5 g of aluminium powder and the mixture ignited.
Calculate the mass of iron that could be produced from this reaction.

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QUESTION 3 (continued)

(c) The products in the above reaction were crushed and the metallic iron was separated magnetically from the aluminium oxide and then dissolved in dilute sulfuric acid. The solution was then made up to 250 cm^3 in a standard flask. 20cm^3 aliquots of this solution were titrated with 0.100M potassium permanganate, $KMnO_4$, until all of the iron was oxidised to iron(III). An average titre of 19.65 cm^3 of $KMnO_4$ was required.

Write the overall balanced equation for the reaction between iron(II) and potassium permanganate in acid solution.

QUESTION 3 (continued)

(d) Calculate the actual mass of iron produced in this reaction and, hence, determine the percentage yield of iron from the thermite reaction.

(e) The thermite reaction is **not** widely used to produce metallic iron from iron oxides. Give one reason why this is so.

QUESTION 4 (10 minutes, 6 marks)
Describe the method that is generally employed to produce metallic iron. You should include in your answer
(1) the reactants used.
(2) the chemical equations for the main reactions taking place.
(3) the methods used to deal with impurities.

QUESTION 5 (13 minutes, 9 marks)

(a) Draw a diagram of a cell in which sodium metal is produced industrially.

Mark clearly on your diagram (1) the anode, (2) the cathode, (3) the electrolyte.

(b) Write balanced equations of the electrode reactions

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QUESTION 5 (continued)

(c) Explain why care must be taken to prevent the mixture of the electrode products.

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(d) Briefly explain why sodium metal cannot be produced by electrolysis of an aqueous solution of a sodium compound.

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QUESTION 6 (14 minutes, 9 marks)

The metals sodium, iron and aluminium undergo corrosion in the atmosphere in varying degrees.

(a) Write three different balanced chemical equations for the reaction of sodium metal with oxygen.

(b) Describe, with the aid of chemical equations, the corrosion and rusting of iron in the presence of oxygen and water.

QUESTION 6 (continued)

(c) Give a reason why the corrosion of aluminium does **not** result in the complete disintegration of the metal while iron, on the other hand, rusts away entirely over a long period of time.

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QUESTION 7 (7 minutes, 5 marks)

Formic acid ionises in aqueous solution to produce hydrogen ions and formate ions according to the equation: $HCOOH(aq) \Leftrightarrow H^+(aq) + HCOO^-(aq)$.

The equilibrium constant, K_c, for this reaction at 25^oC is $10^{-3.74}$ M.

(a) If the equilibrium constant of formic acid, HCOOH, is 10^{-2} M, calculate the hydrogen ion concentration at equilibrium

(b) What is the pH of this solution?

QUESTION 8 (10 minutes, 6 marks)

Aqueous silver ions react with ammonia to form the silver diammine ion according to the equation:
$Ag^{+}(aq) + 2NH_3(aq) \Leftrightarrow Ag(NH_3)_2(aq)$
and for this reaction $\Delta H = -111$ kJ mol^{-1}

(a) Write the equilibrium constant expression for this reaction.

(b) Calculate the equilibrium constant, K_c, for this reaction if, at equilibrium,
$[Ag^{+}] = 2.5 \times 10^{-8}$M, $[Ag(NH_3)_2] = 1$M and $[NH_3] = 2$M.

QUESTION 8 (continued)

(c) Assuming that this reaction is effectively complete, calculate the energy released when 25 cm^3 of a 0.01M silver nitrate solution, $AgNO_3(aq)$, reacts with 0.20 g of ammonia, NH_3.

QUESTION 9 (10 minutes, 6 marks)

(a) From the table of E^o values, draw a diagram of a galvanic cell with an EMF of 2.05 volts. On your diagram, mark clearly the anode, cathode, electrolyte and direction of electron flow.

(b) Describe a method of recharging this cell.

QUESTION 10 (6 minutes, 4 marks)

The metals Al, Cu and Na are added in turn to separate test tubes containing 1M aqueous solutions of Al^{3+}, Cu^{2+} and Na^{+}.

Complete the following table by writing "YES" if a reaction is expected and "NO" if no reaction is expected.

	Al(s)	Cu(s)	Na(s)
$Al^{3+}(aq)$			
$Cu^{2+}(aq)$			
$Na^{+}(aq)$			

END OF 1991 CHEMISTRY YEAR 12 TRIAL EXAM

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SECTION A QUESTION 1 1B 2B 3A 4B 5A 6C 7C 8C 9D 10D 11B 12C 13D 14C 15A 16D 17C 18A 19C 20C 21B 22A 23C 24B 25D 26B 27C 28A 29D 30D 31D 32A 33C 34B 35D 36D 37C 38A

SECTION B QUESTION 2

(1) the method of production is called the Contact Process and the equations are:

(a) $S(s) + O_2(g) \rightarrow SO_2(g)$; (b) $2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g)$;

(c) $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$; (d) $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$

(2) SO_2 is obtainable from many sources including the burning of sulfur and as a byproduct from the roasting of metal sulfide ores.

(3) SO_2 is dried and purified before further oxidation to prevent the poisoning of the catalyst.

(4) SO_2 is heated with air in the presence of V_2O_5 at about 450^oC to give SO_3.

(5) the equilibrium yield of SO_3 is favoured by high pressure, low temperature and a slight excess of air since the reaction is exothermic and involves the production of a smaller number of mole of gas.

(6) a compromise temperature must be used to ensure that the rate of SO_3 production does not become too slow.

(7) in practice, there is little to be gained from the use of high pressure since, at atmospheric pressure, the yield of SO_3 at 450^oC is 98%.

(8) a series of catalyst chambers is used in practice.

(9) the heat of reaction in the formation of SO_3 is used to heat the incoming gases.

(10) SO_3 is absorbed into 98% H_2SO_4 to produce oleum, $H_2S_2O_7$, which is then diluted with water to give H_2SO_4.

(11) direct reaction of SO_3 with water is not used since a fine mist of sulfuric acid results.

(12) sulfuric acid is a strong diprotic acid which ionises according to the equations:

(a) $H_2SO_4(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + HSO_4^-(aq)$

(b) $HSO_4^-(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + SO_4^{2-}(aq)$

(13) sulfuric acid is a dehydrating agent which can be used to dry gases that do not react with it and to remove water from organic compounds such as sugar.

(14) sulfuric acid has a high boiling temperature and therefore can be used to prepare volatile acids such as HCl and HNO_3.

(15) sulfuric acid is a strong oxidant and undergoes reaction in which the oxidation number of sulfur changes from +6 to either +4 (SO_2) or 0 (sulfur element) or -2 (sulfide ion).

(16) sulfuric acid has a wide variety of uses including

(a) preparation of fertilizers such as ammonium sulfate and "superphosphate".
(b) preparation of drugs and insecticides.
(c) cleaning of metal surfaces.

(17) each of the above uses can be related to a particular property of sulfuric acid e.g. its acidic properties are used in the preparation of fertilizers.

QUESTION 3

(a) $Fe_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Fe(l)$

(b) $n(Fe_2O_3) = \frac{10}{160} = 0.0625$ and $n(Al) = \frac{5}{27} = 0.1851$

n(Al) required to react = 2 x $n(Fe_2O_3)$ = 2 x 0.0625 = 0.125

Therefore, the aluminium is in excess. Hence, n(Fe) = 2 x $n(Fe_2O_3)$ = 2 x 0.0625 = 0.125

Hence, m(Fe) = 0.125 x 55.9 = 7.0 g **ANS**

(c) $5Fe^{2+}(aq) \rightarrow 5Fe^{3+}(aq) + 5e^-$ and $MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

Overall equation: $MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$

(d) n(Fe) in 25 cm3 aliquot = n(Fe2+) = 5 x n(MnO4-) = 5 x 0.100 x $\frac{19.65}{1000}$

Therefore, n(Fe) total = 5 x 0.100 x $\frac{19.65}{1000}$ x $\frac{250}{20}$ = 0.1228

m(Fe) = 0.1228 x 55.9 = 6.865 g

% yield of iron = $\frac{6.87}{7.00}$ x 100 = 98.1% **ANS**

(e) Aluminium is too expensive to be used as a reductant for iron(III) oxide.

QUESTION 4 The production of metallic iron is carried out in a blast furnace. The reactants are iron ore (haematite), coke, limestone and air. The chemical equations which summarise this process are:

(1) $C(s) + O_2(g) \rightarrow CO_2(g)$; (2) $CO_2(g) + C(s) \rightarrow 2CO(g)$;

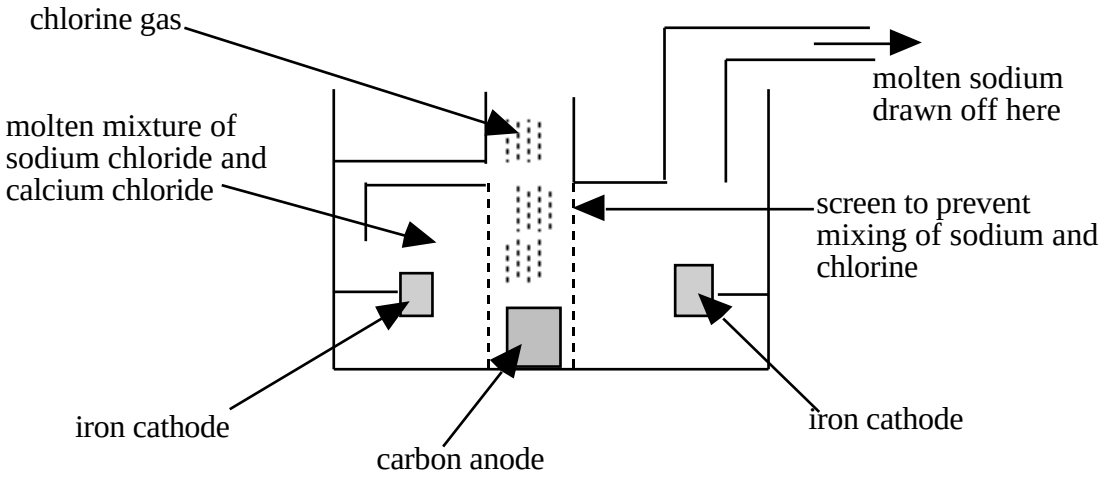
(3) $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$; (4) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$;

(5) $CaO(s) + SiO_2(s) \rightarrow CaSiO_3(l)$.

The blast furnace process is continuous with the reactants fed in at the top of the furnace and molten iron taken out at the bottom. The impurities such as SiO_2 and Al_2O_3 form a slag which floats on top of the molten iron in the form of calcium silicates and aluminates. There is a gradual increase in the temperature of the blast furnace from top to bottom. The iron produced is called "pig iron" and contains many impurities which give it a brittle nature.

QUESTION 5

(a) Schematic diagram for the production of sodium.



(b) ANODE: $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$; CATHODE: $Na^+(l) + e^- \rightarrow Na(l)$

(c) hot sodium and chlorine will react violently to produce sodium chloride.

(d) electrolysis of aqueous sodium solutions gives hydrogen gasat the cathode since water is more easily reduced than sodium ions.

QUESTION 6

(a) (1) $Na(s) + O_2(g) \rightarrow NaO_2(s)$; (2) $2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$;
(3) $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$.

(b) The steps inolved in the corrosion and rusting of iron are:

(1) oxidation of iron $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$;

(2) reduction of dissolved oxygen $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$;

(3) precipitation of iron(II) hydroxide $Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$;

(4) oxidation to iron(III) hydroxide $Fe^{2+}(s) \rightarrow Fe^{3+}(s) + e^-$;

(5) partial dehydration of iron(III) hydroxide $Fe(OH)_3(s) \rightarrow Fe_2O_3.xH_2O(s) + H_2O(l)$.

(c) Aluminium forms an impervious oxide coating which prevents further oxidation of the metal while hydrated iron(III) oxide is permeable to both oxygen and water.

QUESTION 7

(a) $K_c = \frac{[H^+][HCOO^-]}{[HCOOH]} = 10^{-3.74}$ and assuming that $[H^+] = [HCOO^-]$, then $[H^+]^2 = 10^{-3.74} \times 10^{-2} = 10^{-5.74}$. Hence, $[H^+] = 10^{-2.87}$M **ANS**

(b) $pH = -\log_{10} [H^+] = -\log_{10} (10^{-2.87}) = 2.87$ **ANS**

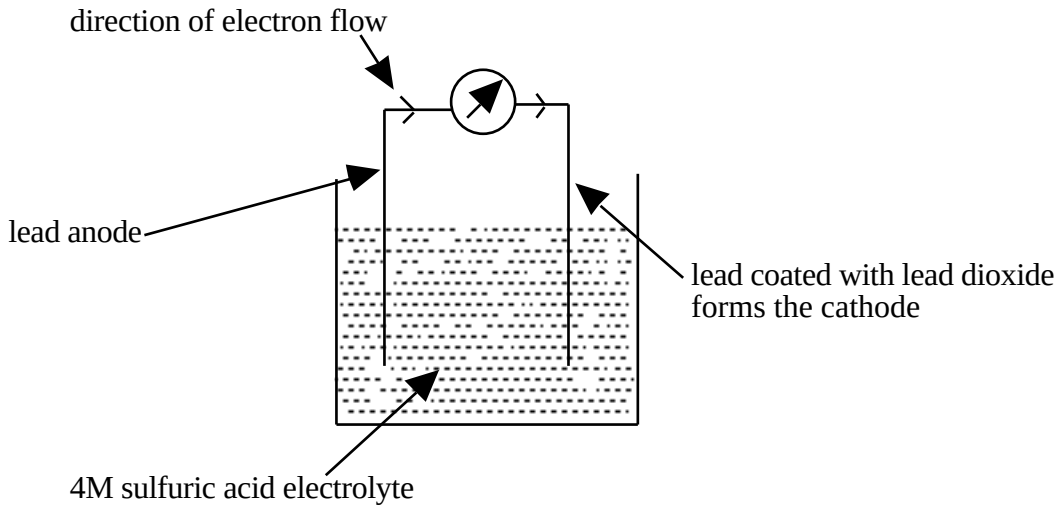
QUESTION 8

(a) $K_c = \frac{[Ag(NH_3)_2^+]}{[Ag^+][NH_3]}$ (b) $K_c = \frac{1}{2.5 \times 10^{-8} \times 2^2} = \frac{1}{10^{-7}} = 10^7\ M^{-2}$ **ANS**

(c) $n(Ag^+) = 0.01 \times 0.025 = 2.5 \times 10^{-4}$ and $n(NH_3) = \frac{0.20}{17} = 0.01176$.

Therefore, $\Delta H = -111 \times 2.5 \times 10^{-4} \times 1000 = -27.75$ J **ANS**

QUESTION 9 (a) The cell required is the lead-acid accumulator as shown below.



(b) To recharge the cell, force electrons through the cell in the opposite direction by using a potential greater than 2.05 volts.

QUESTION 10

	Al(s)	Cu(s)	Na(s)
$Al^{3+}(aq)$	NO	NO	YES
$Cu^{2+}(aq)$	YES	NO	YES
$Na^{+}(aq)$	NO	NO	YES

END OF 1991 CHEMISTRY YEAR 12 TRIAL EXAM SOLUTIONS

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