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NATIONAL EXAMINATION 2001/2002

SUBJECT : CHEMISTRY I

OPTION : BIOLOGY - CHEMISTRY

DURATION : 3 HOURS

INSTRUCTION :

This paper consists of **three** sections : A, B and C.

Answer **all** questions A.

Choose **three** questions from section B.

Choose **one** question from section C.

Calculators may be used.

SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION

(*)

1. Compound A contains the following substances by mass. 22.24% carbon, 3.71% Hydrogen and 74.05% bromine.

(a) Calculate the empirical formula of compound A. (2 marks) *3 marks*

(b) If the relative molecular mass of A is 215.8, what is the molecular formula of A? (1 mark) *2 marks*

(c) Draw the structural formula for anyone of the branched chain isomers of compound A and give its name. (1 mark) *1 mark*

2. Draw diagrams to show the shape of one molecule of each of the following compounds and in the each case state the name of the shape.



You may use the following atomic numbers. (3 Marks)
(Be = 4, B = 5, Si = 14, Cl = 17)

3. (a) Complete the table below. (2 Marks)

	Relative mass	Relative charge
An alpha particle		
A Beta particle		

(b) The decomposition of Hydrogen peroxide $2\text{H}_2\text{O}_2 \longrightarrow 2\text{H}_2\text{O} + \text{O}_2$ is found to be first order reaction.

(i) Write a rate equation for the reaction. (1 Mark)

(ii) Given that the rate constant for the above reaction is $8.25 \times 10^{-4} \text{ s}^{-1}$, calculate the half life $t_{1/2}$ for the reaction. You may use $kt_{1/2} = \ln 2$ where k is the rate constant. (2 Marks)

(iii) How long will it take for the concentration of H_2O_2 to reduce to 25% of its original value? (1 Mark)

4. (a) What do you understand by the standard enthalpy of formation? (1½ Mark)

(b) Use the standard enthalpies of formation in the table below to calculate the standard enthalpy of combustion of Ethane (C_2H_6). (1½ Marks)

Compound	$C_2H_6(g)$	$CO_2(g)$	$H_2O(l)$
Standard enthalpy of formation in $kJmol^{-1}$ at 298 K	-85	-394	-286

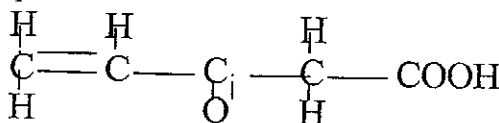
5. (a) Draw & name the structural formula of an isomer of $CH_3CH_2CH=CH_2$ which shows geometrical isomerism. **(1 Mark)**
- (b) Draw the structural geometrical isomer of the named isomer in 5(a) **(1 Mark)**
- (c) Write a mechanism of the reaction showing the formation of the major product when $CH_3CH_2CH=CH_2$ reacts with HCl gas. **(2 Marks)**
6. The table below shows the relative isotopic abundance of the element titanium Ti.

Isotope	^{46}Ti	^{47}Ti	^{48}Ti	^{49}Ti	^{50}Ti
% abundance	8.02	7.31	73.81	5.54	5.32

- (a) Using the information in the table above, calculate the relative atomic mass of titanium. **(2 Marks)**
- (b) State any two dangers that can be caused by radio isotopes. **(1 Mark)**
- (c) Bromine gas contains the isotopes ^{79}Br and ^{81}Br , state and explain the number of peaks formed in the spectrum of bromine molecular ion. **(2 Marks)**
7. Explain the following.
- (a) Phenylamine ($C_6H_5NH_2$) is a weaker base than ethylamine ($CH_3CH_2NH_2$) **(2 Marks)**
- (b) Chloroethanoic acid $CH_2ClCOOH$ is a stronger acid than ethanoic acid CH_3COOH . **(2 Marks)**
8. The table below shows the melting points of elements of period 3. Use the table to answer the questions that follow.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Melting point / $^{\circ}C$	98	650	660	1407	44	119	-101	-189

- (a) Why does magnesium have a higher melting point than sodium? **(2 Marks)**
- (b) Explain the trend (variation) in the first Ionization across period 3. **(2 Marks)**
9. Given the organic compound A.



- (a) Name any two functional groups present in A. (1Mark)
- (b) What would you observe when compound A was reacted with :
- (i) Sodium carbonate. (1Mark)
- (ii) Brady's reagent (2,4-dinitrophenylhydrazine). (1Mark)
- (iii) Fehling's solution. (1 Mark)

10. (a) Write the electronic configuration of the following elements .

- (i) Chromium (1 Mark)
- (ii) Copper (1Mark)

Atomic numbers of chromium and copper are 24 and 29 respectively.

(b) Why are compounds of copper blue? . (2 Marks)

11. Sodium hydride reacts with water according to the following equation:



1 g of a sample of sodium hydride was added to water and the resulting solution was diluted to a volume of 250cm³.

Calculate the concentration in g /dm³ of sodium hydroxide solution formed.
Relative atomic masses are: Na = 23, O = 16, H = 1 (3 Marks)

12. In an experiment to determine the order of a reaction between substance A and substance B, the following results were obtained.

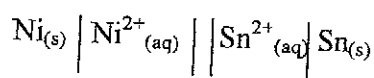
Experiment	[A]/mol dm ⁻³	[B] /mol dm ⁻³	Rate of reaction mol dm ⁻³ min ⁻¹
1	1.0 x 10 ⁻³	1.0 x 10 ⁻³	2. x 10 ⁻⁴
2	2.0 x 10 ⁻³	1.0 x 10 ⁻³	4.0 x 10 ⁻⁴
3	2.0 x 10 ⁻³	2.0 x 10 ⁻³	8 x 10 ⁻⁴

- (a) State the order of reaction with respect to A and to B. (1 Mark)
- (b) Write the rate expression for the reaction. (1 Mark)
- (c) Calculate the rate constant for the reaction showing clearly the units. (2 Marks)

13. Study the following values for standard electrode potentials and answer the questions that follow.

Electrode reaction	Electrode potentials (E^\ominus/V)
$Mn^{2+}_{(aq)} + 2e \rightleftharpoons Mn_{(s)}$	-1.18
$Fe^{2+}_{(aq)} + 2e \rightleftharpoons Fe_{(s)}$	-0.44
$Ni^{2+}_{(aq)} + 2e \rightleftharpoons Ni_{(s)}$	-0.25
$Sn^{2+}_{(aq)} + 2e \rightleftharpoons Sn_{(s)}$	-0.14
$2H^+_{(aq)} + 2e \rightleftharpoons H_{2(g)}$	0.00

- (a) Using the Electrochemical cell set up below,



- (i) Calculate the e.m.f of this cell (1 Mark)
- (ii) Write an equation to show the overall reaction in the cell. (1 Mark)
- (b) Using the standard electrode potentials given, explain whether or not you would expect a reaction to occur if a piece of tin were added to a test tube containing aqueous Iron II sulphate. (2 Marks)

14. Ammonia is manufactured by the Haber-Bosch process according to the equation
- $$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \quad \Delta H = -92 \text{ kJ mol}^{-1}$$

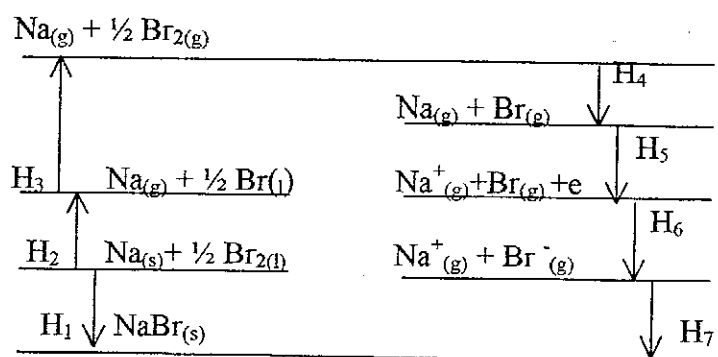
State and explain the effect of high temperatures on:

- (i) The rate of the above reaction. (2 Marks)
- (ii) The yield of ammonia. (2 Marks)

SECTION B

Answer any three questions from this section .

15. The Born Haber's cycle below represents the formation of sodium bromide from its elements in their natural state.



(a) Name the enthalpy changes H_1 to H_7 . (4 Marks)

(b) Given that $H_1 = -361 \text{ KJ mol}^{-1}$, $H_2 = +107 \text{ KJ mol}^{-1}$
 $H_3 = x \text{ KJ mol}^{-1}$, $H_4 = +97 \text{ KJ mol}^{-1}$
 $H_5 = +498 \text{ KJ mol}^{-1}$, $H_6 = -375 \text{ KJ mol}^{-1}$
 $H_7 = -753 \text{ KJ mol}^{-1}$

Calculate the value of H_3 . (3 Marks)

(c) Explain why the enthalpy change H_7 for Na Br is greater than that of KBr
 N.B potassium is below sodium in group I of the periodic table. (3 Marks)

16. (a) Suggest the synthesis routes showing conditions and reagents for the following conversion.

(i) Benzene into 2,4, 6- trinitromethyl benzene. (5 Marks)

(ii) Methanol into Ethanol (5 Marks)

17. Explain the following observation

(a) Reducing power of elements of group VII generally increases down the group. (2 Marks)

(b) The solubility of hydroxides of group II elements increases down the group. (3 Marks)

(c) The boiling points of Hydrides of group VI generally increase down the group, but H_2O has a higher boiling point than expected. (3 Marks)

(d) Lead IV chloride is a covalent compound but lead II chloride is Ionic. (2 Marks)

18. Phenolphthalein is an indicator which is a weak acid. Its pK_a value is 9.3 and its pH range is 8.3 – 10.0. Methyl orange has pK_a value of 3.7 and pH range of 3.1– 4.4.

- (a) State and explain which indicator that can be used in the titration of NaOH against HCl. **(3 Marks)**
- (b) Sketch a titration graph to show the variation of PH of NaOH against the addition of HCl solution and explain the shape of the graph. **(4 Marks)**
- (c) Explain how a mixture of CH_3COONa and CH_3COOH acts as a buffer. **(3 Marks)**
19. 2000cm^3 of sulphur dioxide was mixed with 1000cm^3 of oxygen at 300°C and 10 atmospheres pressure in presence of a catalyst. When equilibrium had been attained, it was found that 1333cm^3 of sulphur dioxide remained.
- (a) Write a balanced equation for the reaction between sulphur dioxide and oxygen. **(1 Mark)**
- (b) State the name of the catalyst. **(1 Mark)**
- (c) Write an expression for the pressure equilibrium constant K_p . **(1 Mark)**
- (d) Calculate the partial pressures of each of the gases at equilibrium. **(4 Mark)**
- (e) Calculate the equilibrium constant for the reaction. **(3 Marks)**

SECTION C

Answer only one question in this section.

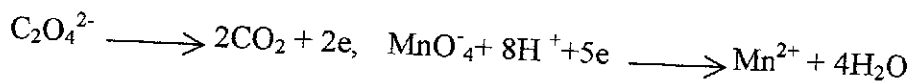
20. With the aid of equations where possible, describe a chemical test you would carry out to distinguish between the following pairs of compounds. In each case, state conditions of the reaction if any and observations that would be made.
- (a) $\text{CH}_3\text{CH}_2\text{NH}_2$ and CH_3CONH_2 . (b) CH_3COCH_3 and CH_3CHO .
- (c) $\text{Pb}^{2+}_{(\text{aq})}$ and $\text{Zn}^{2+}_{(\text{aq})}$ (d) $\text{Cu}^{2+}_{(\text{aq})}$ and $\text{Al}^{3+}_{(\text{aq})}$
- (e) Cl_2 gas and HCl gas. **(3 Marks each)**
21. A solution of potassium tetraethanedioate has the following formula. $(\text{K}_2\text{C}_2\text{O}_4)_x (\text{H}_2\text{C}_2\text{O}_4)_y (\text{H}_2\text{O})_z$ where x , y and z are whole numbers. 25cm^3 of the salt solution of potassium tetraethanedioate were titrated with NaOH solution of concentration 0.1mol dm^{-3} . 23.6cm^3 of NaOH solution were required for complete neutralization. 25cm^3 of the same potassium tetraethanedioate were titrated with potassium manganate VII (KMnO_4) of concentration 0.02mol dm^{-3} in presence of dilute H_2SO_4 .

Given that NaOH only reacts with $\text{H}_2\text{C}_2\text{O}_4$ in the compound and MnO_4^- reacts with all the $\text{C}_2\text{O}_4^{2-}$ Ions in the compound,

Given further that the total concentration of the salt is 8 g dm^{-3} ,

- (a) Calculate the number of moles of Ethanedioate Ions $\text{C}_2\text{O}_4^{2-}$ present in the salt. **(4 Marks)**
- (b) Calculate the number of moles of ethanoic Acid $\text{H}_2\text{C}_2\text{O}_4$. **(4 Marks)**

You may use the following equations.



- (c) Calculate the ratio $x : y : z$ **(7 Marks)**
 relative atomic masses are $\text{K} = 39, \text{C} = 12, \text{O} = 16, \text{H} = 1$

In order to determine the rate of a reaction between CaCO_3 and HCl , the loss in mass of the reaction mixture was measured at different time intervals. The results obtained were as follows.

Time in seconds	0	10	25	50	100	150	200	250	300
Mass lost in dg	0	0.32	0.6	0.83	1.04	1.13	1.19	1.2	1.2

- (a) Sketch a diagram of a complete apparatus that can be used to measure the loss in mass at intervals of time. **(3 Marks)**
- (b) Using the results above, plot a graph of loss in mass versus time (time on x-axis). **(7 Marks)**
- (c) What causes the loss in mass during the reaction? **(1 Mark)**
- (d) Why is the mass lost the same in the last two results? **(1 Mark)**
- (e) From the graph determine the rate of reaction after 80 seconds. **(2 Marks)**
- (f) Deduce the order of the reaction. **(1 Mark)**