Index Number:_____ IM06.20m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2020 FIRST SESSION

SUBJECT:	**Chemistry**
DATE:	30th September 2020
TIME:	4:00 p.m. to 7:05 p.m.

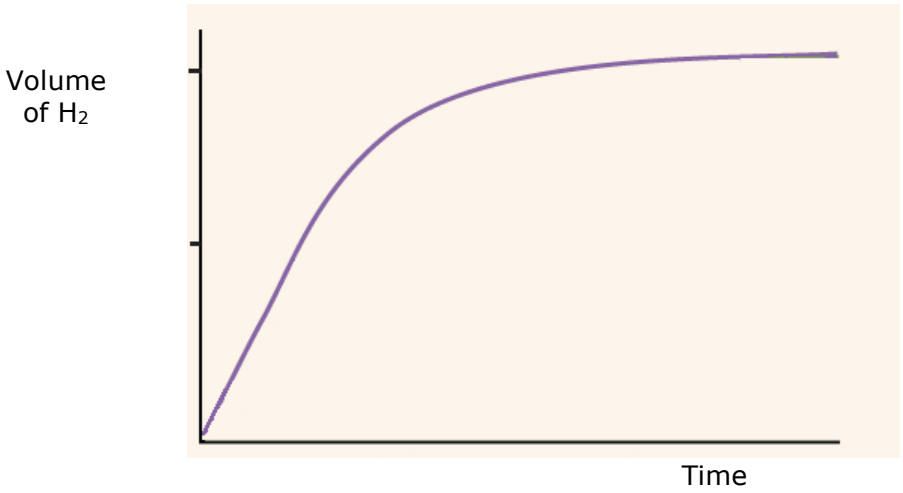
Useful information

Avogadro's constant = 6.02×10^{23} mol^{-1}
Relative atomic masses: H = 1, C =12, O = 16, S = 32, Fe = 56
A Periodic Table is included.

SECTION A

Answer ALL questions in this section.

1. Excess zinc was added to a solution of sulfuric acid of concentration 1.5 $moldm^{-3}$. The volume of the hydrogen produced was plotted against time as shown in the following diagram.



(a) Write a balanced equation for the reaction of zinc and sulfuric acid.

_____ (1)

(b) Explain why the gradient of the curve decreases as the reaction proceeds.

_____

_____ (1)

(c) On the same sketch above, draw another curve which represents the volume of hydrogen produced at a higher temperature. Label this curve High Temp. (½)

(d) On the same sketch above draw another curve which represents the volume of hydrogen produced when using an equal amount of 1 $moldm^{-3}$ sulfuric acid instead of 1.5 $moldm^{-3}$. Label this curve Low Conc. (½)

(Total: 3 marks)

Please turn the page.

2. Thorium-232 (Th-232) is an alpha emitter. Write a balanced equation which represents this decay reaction of Thorium-232.
   Hint: Use the periodic table to write the appropriate symbol of the product in the equation.

_____ (3)

(Total: 3 marks)

3. The Avogadro's constant L is equal to 6.02×10^{23} mol^{-1}.
   (a) Use the above information to calculate the number of molecules in 3.2 g of methane.

_____

_____

_____ (3)

   (b) Find the total number of atoms present in 3.2 g of methane.

_____ (1)

(Total: 4 marks)

4. (a) The hydrogen ion concentration of a sample of an anti-dandruff shampoo A is 1.58×10^{-6} $moldm^{-3}$. Calculate the pH of this shampoo.

_____

_____ (3)

   (b) A lower acidity in shampoos is observed to cause less hair frizzing. A paediatric shampoo B – advertised as a 'no tears' shampoo – has a pH of 7. Which of the two shampoos A or B, would cause less frizzing? Explain your answer.

_____

_____ (1)

(Total: 4 marks)

5. The oxides of the elements in Period 3 have different structures at room temperature (RT), show different types of bonding and react differently with water.
   Fill in the missing words in the grid below. In the last column (Reaction with water), choose between the following options: produces alkaline solution, produces acidic solution or does not react.

Period 3 Oxide	**Structure at RT**	**Bonding**	**Reaction with water**
sodium oxide	giant lattice		produces alkaline solution
	simple molecular	covalent	
		predominantly ionic	does not react
magnesium oxide			

(Total: 4 marks)

6. In an experiment, a piece of zinc metal is placed in an aqueous solution of copper sulfate. In this reaction copper metal is displaced.

(a) Write a fully balanced equation with state symbols for the above reaction.

_____ (2)

(b) Write an ionic equation for the above reaction.

_____ (1)

(c) What would be observed in the above reaction?

_____

_____ (1)

(Total: 4 marks)

7. Write down the structural formulae of **all** isomers of but-2-ene and name them.

(Total: 4 marks)

Please turn the page.

8. A phase change occurs whenever the physical state of a substance changes. A student slowly warmed a piece of ice, originally at -10 °C and normal atmospheric pressure to 100 °C.

(a) Draw a diagram to show the molecular structure of ice, including intermolecular forces, at -10 °C. (½)

(b) Name and label, on the diagram in part (a), the strong intermolecular forces which are important for the structure of ice. (½)

(c) How are these intermolecular forces formed?

_____

_____ (1)

(d) Draw diagrams to show water molecules and strong intermolecular bonding (if any) at: (i) 10 °C; and (ii) 100 °C. (1)

(e) The presence of these strong intermolecular forces give water anomalous (abnormal) properties. Describe **ONE** of these properties.

_____ (1)

(Total: 4 marks)

SECTION B

Answer ALL questions in this section.

9. In this question, you will calculate the percentage of iron in 1.6 g of steel.
   (a) Give the oxidation state of each the following elements:

Mn in Mn^{2+} _____ (½)

Mn in MnO_4^- _____ (½)

   (b) Potassium manganate(VII) oxidises iron(II) in acid to iron(III). Write balanced ionic half equations to show the oxidation of iron(II) and the reduction of the manganate.

_____ (½)

_____ (½)

   (c) Write a fully balanced equation of the reaction between iron(II) and potassium manganate(VII).

_____ (½)

   (d) 1.6 g of steel was dissolved in hydrochloric acid and diluted to exactly 250 cm^3 with water in a volumetric flask. In this process the iron is oxidised to iron(II). Write an equation for the reaction between the iron and the hydrochloric acid.

_____ (½)

   (e) In a titration experiment, a 25.00 cm^3 portion of the above solution required 28.00 cm^3 of 0.02 $moldm^{-3}$ potassium manganate(VII) solution for complete oxidation.
      (i) Calculate the number of moles of manganate(VII) used in the titration.

_____

_____ (½)

      (ii) Calculate the number of moles of iron which reacted with 28.00 cm^3 of potassium manganate(VII).

_____

_____ (1)

      (iii) Calculate the number of moles of iron present in the original steel sample.

_____

_____ (½)

      (iv) Calculate the percentage by mass of iron in the steel.

_____

_____ (1)

(Total: 6 marks)

10. An equilibrium mixture in the Haber process was found to contain 0.90 moles of nitrogen, 3.00 moles of hydrogen and 0.20 moles of ammonia at a temperature of 660 K and a pressure of 5000 kPa.

(a) Write a fully balanced equation for the above reaction. (Place the diatomic gases on the left-hand side of the equation.)

_____ (1)

(b) Calculate the mole fraction of each gas in the mixture.

_____

_____

_____ (1)

(c) Calculate the partial pressure of each gas in the mixture.

_____

_____

_____ (1½)

(d) Write the expression for the equilibrium constant K_p for the reaction in part (a).

_____

_____ (1)

(e) Write the units for K_p.

_____

_____ (½)

(f) Calculate a value for the equilibrium constant K_p for the Haber process reaction at 660 K.

_____

_____

_____ (1)

(Total: 6 marks)

11. The following table gives the carbon-carbon bond lengths in different compounds.

Bond	Bond length in nm
C-C	0.154
C=C	0.134
Benzene C-C	0.139

(a) Explain why the carbon-carbon bond lengths in the above table differ.

_____

_____

_____

_____

_____

_____

_____

_____ (1½)

(b) Which carbon to carbon bond from the above table is the most reactive?

_____ (½)

(c) Write a fully balanced equation for a reaction which shows the reactivity of the C=C bond in a 3-carbon compound of your choice.

_____ (1)

(d) Why does benzene readily undergo substitution reactions but not addition reactions?

_____

_____ (1)

(e) Give **ONE** example, stating the conditions, of a substitution reaction of benzene.

_____

_____

_____ (2)

(Total: 6 marks)

Please turn the page.

12. The following four reagents are available for the qualitative analysis of solutions in parts (a) to (e) below: an aqueous solution of sodium hydroxide; an aqueous solution of ammonia; a dilute solution of hydrochloric acid; and an aqueous solution of barium chloride. Describe how the following pairs of compounds in parts (a) to (e) may be distinguished by using any of these four reagents.

(a) Potassium chloride and magnesium chloride.

_____

_____

_____ (1)

(b) Zinc nitrate(V) and lead nitrate(V).

_____

_____

_____

_____ (1)

(c) Chromium sulfate and copper sulfate.

_____

_____

_____

_____ (1)

(d) Sodium carbonate and sodium thiosulfate.

_____

_____

_____

_____ (1)

(e) Magnesium sulfate(VI) and magnesium nitrate(V).

_____

_____

_____ (1)

(f) (i) Write an ionic equation for a reaction which occurs in part (b).

_____ (½)

(ii) Write an ionic equation for a reaction which occurs in part (e).

_____ (½)

(Total: 6 marks)

13. (a) Monomers join together to form polymers. Explain.

_____

_____

_____ (1)

(b) Ethene, an alkene, forms polyethene.

(i) Write down a chemical equation to show this reaction. Start with n monomers and include **THREE** monomer units in the product.

_____ (1)

(ii) What is this type of reaction called, and so what is this type of polymerisation called?

_____ (1)

(c) (i) An alcohol and a carboxylic acid react to give an ester. Give the equation for the reaction between ethanol and ethanoic acid, indicating any conditions.

_____

_____ (1)

(ii) Polyester is another polymer. It is formed by a different type of polymerisation reaction with respect to polyethene. What type of reaction is involved in this case, and so what is this type of polymerisation called?

_____ (1)

(iii) The monomers involved in this type of polymerisation are polyfunctional molecules. Explain the term 'polyfunctional molecule'.

_____

_____ (1)

(Total: 6 marks)

Please turn the page.

SECTION C

Answer any TWO questions from this section. Write your answers on the lined pages of this booklet.

14. There is a trend in the oxidising ability of the group 7 elements.
    (a) Distinguish between oxidation and reduction, in terms of exchange of electrons and in terms of oxidation numbers. (2)
    (b) Considering chlorine, bromine and iodine, explain the relative oxidising power of the three halogens through the following sets of reactions:
        - the reactions of chlorine with bromide and iodide;
        - the reaction of bromine with iodide.

        In each of the three cases, give the relevant ionic equations (including state symbols) and indicate the oxidising agent and what is oxidised and reduced.
        Thus explain the relative oxidising power, indicating clearly which of the three halogens has the highest oxidising power. (10)
    (c) (i) Explain how hydrogen chloride can be produced, indicating any conditions. Give the chemical equation, including state symbols, that represents the reaction. (3)
        (ii) Comment on the acidity of the aqueous solutions of the hydrogen halides of chlorine, bromine and iodine. (1)
    (d) Sodium chlorate(I) – or sodium hypochlorite – is a chemical compound with the formula NaOCl, comprising a sodium cation and a chlorate(I) anion.
        (i) Find the oxidation number of Cl in NaOCl. (2)
        (ii) Explain the (I) in the compound's name. (1)
        (iii) Give **TWO** uses of NaOCl. (1)

(Total: 20 marks)

15. Consider the reactions of sulfur and nitrogen with oxygen:

$$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)} \quad \Delta H = -296 \text{ kJmol}^{-1}$$

$$N_{2(g)} + 2O_{2(g)} \longrightarrow 2NO_{2(g)} \quad \Delta H = +67.6 \text{ kJmol}^{-1}$$

    Both products are dioxides: sulfur dioxide and nitrogen dioxide respectively.
    (a) One of the reactions is endothermic while the other is exothermic. Indicate which is which, and explain the difference in notation. (2)
    (b) Using the two reactions above, explain the difference between an endothermic reaction and an exothermic reaction in terms of energy exchange. (2)
    (c) Consider the reaction of sulfur with oxygen, and the relative ΔH value.
        (i) What is this type of reaction called? (1)
        (ii) Explain the term $\Delta H = -296 \text{ kJmol}^{-1}$. (1)
        (iii) How many grammes of sulfur dioxide are produced for this value of energy change? (1½)
        (iv) How many grammes of sulfur must react with oxygen for this value of energy change? (1)
        (v) If 8 g of sulfur react completely with oxygen, find out how many moles of SO_2 are produced? (2)
        (vi) If 8 g of sulfur react completely with oxygen, find out the energy released? (1½)
    (d) A certain volume of 0.5 moldm^{-3} hydrochloric acid solution reacts with 25.0 cm^3 of 0.25 moldm^{-3} sodium hydroxide solution.
        (i) Write a chemical equation, including state symbols, that represents the reaction between hydrochloric acid solution and sodium hydroxide solution. (1)
        (ii) Find the number of moles of sodium hydroxide in 25.0 cm^3 of 0.25 moldm^{-3} sodium hydroxide solution. (1½)
        (iii) Find the volume of 0.5 moldm^{-3} hydrochloric acid solution that reacts with 25.0 cm^3 of 0.25 moldm^{-3} sodium hydroxide solution. (2½)
        (iv) If the heat of neutralisation for the above reaction is -57.0 kJmol^{-1}, find the energy change in J for this reaction. (3)

(Total: 20 marks)

16. (a) Consider an aqueous solution of sodium chloride. Distinguish between the solute, the solvent and explain the term solution in this case. (2)
    (b) The measurement of the melting point and the boiling point of a substance can be used as a criterion of purity of the substance. Discuss. (2)
    (c) For each of the following separation techniques, give: (i) a labelled diagram of the apparatus used; and (ii) a mixture that can be separated by the given technique.
        - Filtration; (5)
        - Sublimation; (5)
        - Distillation. (6)

(Total: 20 marks)

17. (a) Compounds of transition metals show different colours. Illustrate by considering Cu^{+} and Cu^{2+} compounds for copper and Fe^{2+} and Fe^{3+} compounds for iron. (4)
    (b) Transition elements and their compounds also show catalytic properties.
        (i) The decomposition of hydrogen peroxide needs a catalyst to enhance the rate of reaction. Give the chemical equation, including state symbols, and the catalyst used for the reaction taking place. (3)
        (ii) The hydrogenation of unsaturated hydrocarbons is also catalysed. Give the chemical equation, including state symbols, of a suitable example and the catalyst used for the reaction taking place. (3)
    (c) (i) Transition elements also form complex ions. Examples are: $[Fe(H_2O)_6]^{2+}$, $[Cu(NH_3)_4]^{2+}$, $[Zn(NH_3)_4]^{2+}$ and $[Fe(CN)_6]^{3-}$.
        For each draw a diagram of the shape, and give its name. (8)
        (ii) In complex ions, metal-ligand bonding can be described in terms of the electrostatic model or dative covalent (coordinate) bonding.
        Explain the term dative covalent (coordinate) bonding. Considering $[Fe(H_2O)_6]^{2+}$, indicate the ligand. (2)

(Total: 20 marks)

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PERIODIC TABLE

I	II											III	IV	V	VI	VII	VIII
1 **H** 1																	4 **He** 2
7 **Li** 3	9 **Be** 4											11 **B** 5	12 **C** 6	14 **N** 7	16 **O** 8	19 **F** 9	20 **Ne** 10
23 **Na** 11	24 **Mg** 12											27 **Al** 13	28 **Si** 14	31 **P** 15	32 **S** 16	35.5 **Cl** 17	40 **Ar** 18
39 **K** 19	40 **Ca** 20	45 **Sc** 21	48 **Ti** 22	51 **V** 23	52 **Cr** 24	55 **Mn** 25	56 **Fe** 26	59 **Co** 27	59 **Ni** 28	63.5 **Cu** 29	65 **Zn** 30	70 **Ga** 31	73 **Ge** 32	75 **As** 33	79 **Se** 34	80 **Br** 35	84 **Kr** 36
85 **Rb** 37	88 **Sr** 38	89 **Y** 39	91 **Zr** 40	93 **Nb** 41	96 **Mo** 42	99 **Tc** 43	101 **Ru** 44	103 **Rh** 45	106 **Pd** 46	108 **Ag** 47	112 **Cd** 48	115 **In** 49	119 **Sn** 50	122 **Sb** 51	128 **Te** 52	127 **I** 53	131 **Xe** 54
133 **Cs** 55	137 **Ba** 56	139 **La** 57	178.5 **Hf** 72	181 **Ta** 73	184 **W** 74	186 **Re** 75	190 **Os** 76	192 **Ir** 77	195 **Pt** 78	197 **Au** 79	201 **Hg** 80	204 **Tl** 81	207 **Pb** 82	209 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
223 **Fr** 87	226 **Ra** 88	227 **Ac** 89															

Key

Relative atomic mass — A
X
Z — *Atomic Number*

140 **Ce** 58	141 **Pr** 59	144 **Nd** 60	147 **Pm** 61	150 **Sm** 62	152 **Eu** 63	157 **Gd** 64	159 **Tb** 65	162 **Dy** 66	165 **Ho** 67	167 **Er** 68	169 **Tm** 69	173 **Yb** 70	175 **Lu** 71
232 **Th** 90	231 **Pa** 91	238 **U** 92	237 **Np** 93	244 **Pu** 94	243 **Am** 95	247 **Cm** 96	247 **Bk** 97	251 **Cf** 98	252 **Es** 99	257 **Fm** 100	258 **Md** 101	259 **No** 102	260 **Lr** 103