Index Number:_____ IM06.21m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2021 FIRST SESSION

SUBJECT:	**Chemistry**
DATE:	30th June 2021
TIME:	9:00 a.m. to 12:05 p.m.

Useful information
Ideal gas constant = 8.314 $JK^{-1}mol^{-1}$
Relative atomic masses: H = 1, C = 12
A Periodic Table is included.

SECTION A
Answer ALL questions in this section.

1. Write the electron configurations in terms of s, p, d of the following:

   (a) sodium: _____ (½)

   (b) chlorine: _____ (½)

   (c) each of the **TWO** ions in the ionic compound sodium chloride:

   (i) the cation: _____ (1)

   (ii) the anion: _____ (1)

(Total: 3 marks)

2. Complete the following table:

	Atomic number	Neutron number	Electron number
$^{19}_{9}F^-$			
$^{180}_{72}Hf^{2+}$			

(Total: 3 marks)

3. Mark the following statements as True or False:

		True	False
(a)	The ions in an ionic compound are regularly arranged in a lattice with the oppositely charged ions close to each other.		
(b)	Weak electrostatic forces hold the positive ions and the negative ions in ionic compounds together.		
(c)	Ionic compounds have high melting points.		
(d)	Ionic compounds conduct electricity in the solid state.		

(Total: 4 marks)

4. The boiling points of methane and ethanol are 109 K and 352 K respectively. Explain in terms of intermolecular forces:

   (a) What happens when a liquid changes phase to a gas?

_____ (1)

   (b) Why does methane have a much lower boiling point than ethanol?

_____

_____

_____

_____ (3)

(Total: 4 marks)

5. When hydrogen reacts with iodine in a closed tube at 500 K, the following equilibrium is set up: H_2 (g) + I_2 (g) ⇌ HI (g)

   (a) Write an expression for K_c for the above equilibrium.

_____

_____ (1)

   (b) If the concentrations of hydrogen, iodine and hydrogen iodide at equilibrium are 1.10×10^{-3} moldm^{-3}, 2.00×10^{-3} moldm^{-3} and 18.80×10^{-3} moldm^{-3} respectively, calculate K_c and give its units, if any.

_____

_____

_____ (2)

   (c) In another experiment at 500 K, the concentrations of the hydrogen and iodine were both reduced to 0.5×10^{-3} mol dm^{-3}. Estimate the value of K_c.

_____ (1)

(Total: 4 marks)

6. Four jars with colourless solutions were labelled as 1 moldm^{-3} HCl (aq), 0.1 moldm^{-3} HCl (aq), 0.1 moldm^{-3} CH_3COOH (aq) and 0.1 moldm^{-3} KOH (aq) respectively.

(a) Which jar has the lowest pH?

_____ (½)

(b) Explain the difference, if any, in the value of pH of 0.1 moldm^{-3} KOH (aq) and of 0.1 moldm^{-3} HCl (aq).

_____

_____

_____ (2)

(c) Explain the difference, if any, in the value of pH of 0.1 moldm^{-3} CH_3COOH (aq) and of 0.1 moldm^{-3} HCl (aq).

_____

_____ (1½)

(Total: 4 marks)

7. (a) Consider the following pairs. Underline the species with the larger radius in each pair.
   (i) A sodium atom and a chlorine atom.
   (ii) A lithium atom and a lithium ion Li^+.
   (iii) A sulfur atom and a sulfur ion S^{2-}.
   (iv) A sodium ion Na^+ and a magnesium ion Mg^{2+}. (2)

(b) Silicon and sulfur are elements in Period 3 of the Periodic Table. The melting points of silicon and sulfur are 1683 K and 392 K respectively. Explain why sulfur has a lower melting point than silicon.

_____

_____

_____

_____ (2)

(Total: 4 marks)

Please turn the page.

8. Two different compounds A and B are hydrocarbons and isomers of each other. They were analysed and were found to have 85.71% carbon and 14.29% hydrogen.

(a) Find the empirical formula of A and B.

_____

_____

_____

_____ (1)

(b) Both A and B had a molar mass of 84 $gmol^{-1}$. Find the molecular formula of A and B.

_____

_____

_____

_____ (1)

(c) Further analysis showed that A did not react with chlorine in the dark, whereas B rapidly decolorised chlorine in the dark. Suggest a structure for isomer A and a structure for isomer B.

(2)

(Total: 4 marks)

SECTION B

Answer ALL questions in this section.

9. Propane and propan-1-ol are two organic compounds which are used as a fuel. The combustion of each of the two organic compounds releases carbon dioxide and water vapour.

   (a) Write a balanced chemical equation for the combustion of the alkane.

_____ (1½)

   (b) Write a balanced equation for the combustion of the alcohol.

_____ (1½)

   (c) 10 cm^3 of a gaseous organic compound C required 45 cm^3 of oxygen for complete combustion, both volumes measured at temperatures above the boiling points of the organic compounds. State whether compound C is propane or propan-1-ol.

_____(1)

   (d) Give a reason for your answer in part (c) and name the appropriate chemical law which you have applied for your reasoning.

_____

_____

_____

_____(2)

(Total: 6 marks)

Please turn the page.

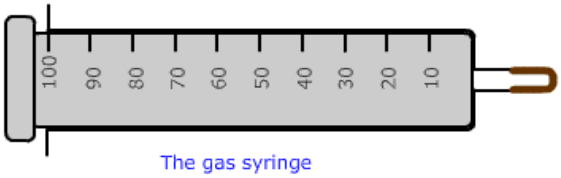
10. The ideal gas equation can be used to find the molar mass of a gas.

(a) Write the modified version of the ideal gas equation which includes the molar mass of a gas as one of the terms.

_____

_____ (½)

(b) The gas syringe experiment is used to calculate the molar mass of a gas G.



The gas syringe

Adapted from https://ibchem.com/IB16/12.03.htm

State how the values of each of following variables are obtained in the experiment.

(i) The pressure: _____

_____ (½)

(ii) The temperature: _____

_____ (½)

(iii) The volume of gas G: _____

_____ (½)

(iv) The mass of gas G in the syringe: _____

_____

_____

_____ (2½)

(c) In a gas syringe experiment, 100 cm^3 of gas at 18 ^oC and 100,275 Nm^{-2} weighed 0.1824 g. Calculate the molar mass of the gas.

_____

_____

_____

_____ (1½)

(Total: 6 marks)

11. (a) Boron trifluoride and ammonia are both covalent compounds.

(i) Draw a diagram of each of the above covalent molecules, showing their shape and any lone pairs of electrons.

(2)

(ii) Name the shapes of the boron trifluoride and the ammonia molecules and state the bond angles of each molecule.

_____

_____(2)

(b) An ammonia molecule and a boron trifluoride molecule can bond together by the formation of a dative (co-ordinate) bond.

(i) Explain how a dative (co-ordinate) bond is formed.

_____

_____

_____(1)

(ii) Draw a dot-cross diagram to show the bonding in the molecule formed between ammonia and boron trifluoride.

(1)

(Total: 6 marks)

Please turn the page.

12. Three small pieces of zinc weighing 1 g and 100 cm^3 of 1 $moldm^{-3}$ hydrochloric acid were placed in a flask at 25 ^oC. The volume of hydrogen released was measured at regular intervals to determine the initial rate of the reaction.
Explain how each of the following changes would affect the rate of the reaction. (In your answer, first state whether the rate increases, decreases or stays the same and then give an explanation for your choice.)

(a) The temperature is increased to 35 ^oC.

_____

_____

_____

_____ (1½)

(b) A volume of 100 cm^3 of 0.5 $moldm^{-3}$ hydrochloric acid is used.

_____

_____

_____

_____(1)

(c) The zinc is replaced by magnesium.

_____

_____

_____

_____ (1½)

(d) 1 g of granulated zinc is used instead of 1 g of zinc cut into 3 pieces.

_____

_____

_____(1)

(e) The hydrochloric acid is replaced by ethanoic acid of the same concentration.

_____

_____

_____

_____(1)

(Total: 6 marks)

13. Chromatography is the method of separating two or more components of a mixture using a solvent.

(a) Draw a well-labelled diagram to show the apparatus used for paper chromatography. In your diagram, include the prepared chromatography paper with the mixture spot.

(3)

(b) A team of analysts investigated the presence of banned dyes in a green food colouring Y by a comparison method. They used a chromatogram of Y and of the banned dyes P, Q, R and S. The analysts concluded that:

1. Sample Y is a mixture of three components.
2. Dye P, dye Q and dye R are pure, but dye S is a mixture of two other dyes.
3. Sample Y contains the banned dyes R and S, but not dyes P and Q.

Two spots for dye R have been marked in the following representation of the analysts' chromatogram. Use the above conclusions to complete the chromatogram for Y, P, Q and S.

(3)

					*	
					*	
	Y	**P**	**Q**	**R**	**S**	
Solvent						

(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. This question is about energetics.

(a) Methanol burns as shown by the equation below:

$$CH_3OH(l) + 1½O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Use the mean bond enthalpy data given in the Table below to answer the following questions:

Bond	Mean bond enthalpy ($kJmol^{-1}$)
C – H	+413
C – O	+358
O – H	+464
O = O	+498
C = O	+736

(i) Calculate the enthalpy change which occurs when **all** the bonds in the reactants shown in the above equation are broken. (4)

(ii) Calculate the enthalpy change which occurs when **all** the bonds in the products shown in the above equation are formed. (4)

(iii) Hence, calculate the enthalpy change for the complete combustion of methanol as shown in the equation above. (2)

(b) Write the equations for:

(i) the enthalpy change of formation of ethene; (1)

(ii) the enthalpy change of combustion of carbon; (1)

(iii) the enthalpy change of combustion of hydrogen; (1)

(iv) the enthalpy change of combustion of ethene. (1)

(c) Join the four chemical equations given as answers to parts b(i) to b(iv) above to construct a Hess' cycle. (3)

(d) If the enthalpy change of combustion of carbon, hydrogen and ethene at 298 K are -394 kJ/mol, -286 kJ/mol and -1393 kJ/mol respectively, calculate the enthalpy change of formation of ethene. (3)

(Total: 20 marks)

15. This question is about a number of organic compounds.

Write short notes about each of the following statements. Include chemical equations and any observations wherever necessary.

(a) Alcohols undergo dehydration to give alkenes and ethers. (6)

(b) Alcohols react with carboxylic acids to give esters. (3)

(c) Both alcohols and carboxylic acids react with PCl_5. (3)

(d) There are two different organic compounds with the same molecular formula C_3H_8O. (3)

(e) Nitrobenzene can be converted to phenylamine. (5)

(Total: 20 marks)

16. This question is about redox reactions.
Explain each of the following statements. Include chemical equations wherever necessary.
(a) There are redox reactions, and they can be explained in terms of electron exchange. One such example is the reaction between sodium and chlorine to give sodium chloride. (5)
(b) A disproportionation reaction is a 'special' kind of redox reaction. Illustrate your answer – using oxidation numbers – by considering the reaction: $2Sn^{2+} \rightarrow Sn^{4+} + Sn$. (5)
(c) Magnesium and gold are both metals, but they react differently with hydrochloric acid. (4)
(d) One speaks of the relative oxidising ability of the halogens chlorine, bromine and iodine as we go down the group. (6)

(Total: 20 marks)

17. This question involves calculations for a back titration exercise.
A student was asked to determine the concentration of ammonia in a commercially available cleaning product. She pipetted 25.0 cm^3 of the cleaning product into a conical flask and immediately added 50.0 cm^3 of 0.10 $moldm^{-3}$ hydrochloric acid solution to it, which reacted with the ammonia in the solution of the cleaning product. The reaction between ammonia and hydrochloric acid can be represented by:

$$NH_4OH\ (aq) + HCl\ (aq) \rightarrow NH_4Cl\ (aq) + H_2O\ (l)$$

The unreacted hydrochloric acid was then titrated with 0.05 $moldm^{-3}$ sodium carbonate solution.
(a) Write down the balanced equation, including state symbols, for the reaction between sodium carbonate solution and hydrochloric acid solution. (2)
(b) The volume of 0.05 $moldm^{-3}$ sodium carbonate solution required to react with the unreacted hydrochloric acid was 22.0 cm^3.
(i) Calculate the number of moles of unreacted hydrochloric acid. (4)
(ii) Calculate the total number of moles in 50.0 cm^3 of 0.10 $moldm^{-3}$ hydrochloric acid solution. (2)
(iii) Calculate the number of moles of hydrochloric acid solution that reacted with the ammonia in the 25.0 cm^3 of the cleaning product. Calculate also the number of moles of ammonia in the 25.0 cm^3 of the cleaning product. (4)
(iv) Thus, calculate the concentration of ammonia in the cleaning product. (2)
(c) A similar cleaning product was tested, and the volume of 0.05 $moldm^{-3}$ sodium carbonate solution required to react with the unreacted hydrochloric acid was 25.0 cm^3. Which of the two products is more concentrated in ammonia? Show all the working. (6)

(Total: 20 marks)

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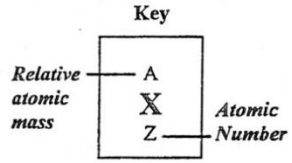
PERIODIC TABLE



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															

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