Index Number:_____ IM06.18m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2018 FIRST SESSION

SUBJECT:	**Chemistry**
DATE:	23rd May 2018
TIME:	9:00 a.m. to 12:05 p.m.

Useful information

Relative atomic masses: Cl = 35.5, Fe = 56, I = 127, Pb = 207
A Periodic Table is included.

SECTION A

Answer ALL questions in this section.

1. (a) The following table gives information on two naturally occurring isotopes of sulfur. List the number of neutrons, electrons and protons which are found in each isotope.

Isotope	Number of neutrons	Number of electrons	Number of protons	Natural abundance as %
$^{32}_{16}S$				95.0
$^{34}_{16}S$				4.2

(1)

(b) Use the information in the above table and estimate the atomic mass of sulfur to two significant figures.

_____

_____

_____ (1)

(c) Why is your answer an estimate?

_____

_____ (1)

(Total: 3 marks)

2. Explain the following in terms of the kinetic theory of gases.
   (a) What happens to the pressure of a fixed volume of air in a bicycle tyre if the temperature increases?

_____

_____

_____ (1½)

   (b) What happens to the pressure of a fixed amount of air in a gas syringe, if at the same temperature, its volume is halved?

_____

_____

_____ (1½)

(Total: 3 marks)

3. This question is about a flexible leak-proof balloon.
   (a) A balloon of volume 700 dm^3 was filled with helium to a pressure of 1 x 10^5 Nm^{-2} at 20 ^oC. Calculate the number of moles of helium in the balloon.

_____

_____

_____ (2)

   (b) The same balloon was then allowed to ascend to an altitude where the helium pressure decreased to 5.00 x 10^4 Nm^{-2}. At this pressure the balloon volume increased to 900 dm^3. Calculate the atmospheric temperature in ^oC at this altitude.

_____

_____

_____ (2)

(Total: 4 marks)

4. (a) Write the formula of each of the following:

   (i) the chloride of magnesium _____ (½)

   (ii) the chloride of silicon _____ (½)

   (b) Write balanced chemical equations (with state symbols) to show what happens when water is added to:
   (i) the chloride of magnesium

_____ (1½)

   (ii) the chloride of silicon

_____ (1½)

(Total: 4 marks)

5. (a) State which one of the following two mixtures, A and B, would react?
   A: Liquid bromine added to a solution of sodium chloride in water; or
   B: Chlorine gas bubbled through a solution of sodium iodide.

_____ (1)

(b) Give reasons for your choice to part (a).

_____

_____

_____ (2)

(c) Write a balanced chemical equation (with state symbols) for the mixture which reacts.

_____ (1)

(Total: 4 marks)

6. The following table gives the molar mass and the boiling point of three organic compounds X, Y and Z.

	Compound	Molar mass in g	Boiling point in K
X.	Butan-1-ol	74	391
Y.	2-methylpropan-1-ol	74	381
Z.	ethoxyethane	74	308

(a) Draw the chemical structures of the three compounds

X:

Y:

Z:

(1½)

(b) Explain why the three compounds with the same molar mass have different boiling points.

_____

_____

_____ (2½)

(Total: 4 marks)

7. Five jars, each known to contain one of the five nitrates of calcium, aluminium, sodium, silver, and zinc were stored without labels. One cation of one of the salts has been identified and listed in the following table. Complete the table to explain how, with the use of aqueous sodium hydroxide and aqueous ammonia, you were able to identify the other cations in the other salts.

Addition of aqueous sodium hydroxide to each nitrate, dropwise and then in excess	**Addition of aqueous ammonia to each nitrate, dropwise and then in excess**	**Identified cation in compound in jar**
White precipitate insoluble in excess NaOH	White precipitate insoluble in excess NH_3	*This indicates* Ca^{2+}
White precipitate soluble in excess NaOH	White precipitate insoluble in excess NH_3	
No precipitate was formed	No precipitate was formed	
A dark brown precipitate	A brown precipitate soluble in excess giving a colourless solution	
White precipitate soluble in excess NaOH	White precipitate soluble in excess NH_3	

(Total: 4 marks)

8. Butanoic acid is four times more soluble in ether than it is in water. This property of butanoic acid can be used in a technique where ether is used to separate butanoic acid from an aqueous solution.

(a) (i) Name this separation technique _____ (½)

(ii) Draw and label the apparatus which is required in this separation technique.

(1½)

(b) Outline the procedure in this separation technique.

_____

_____

_____

_____ (2)

(Total: 4 marks)

SECTION B

Answer ALL questions in this section.

9. (a) Lead(II) nitrate solution reacts with potassium iodide solution to form solid lead(II) iodide. 25 cm^3 of lead nitrate of concentration 1.00 $moldm^{-3}$ were added to the potassium iodide solution of concentration 0.500 $moldm^{-3}$.

(i) Write a balanced chemical ionic equation (with state symbols) for the reaction between lead(II) nitrate and potassium iodide.

_____ (1)

(ii) Calculate the number of moles of lead(II) nitrate which were used in the reaction.

_____ (1)

(iii) Calculate the number of moles of potassium iodide which were needed to react with the lead(II) nitrate.

_____ (1)

(iv) Calculate the exact volume of the potassium iodide which was required for this reaction.

_____ (1)

(b) Calculate the mass of lead(II) iodide which would be precipitated if 120 cm^3 of potassium iodide solution (0.500 $moldm^{-3}$) are mixed with 25 cm^3 of lead(II) nitrate solution (1.00 $moldm^{-3}$).

_____

_____

_____

_____ (2)

(Total: 6 marks)

10. The kinetics of the following reaction between gaseous hydrogen and gaseous iodine, at a particularly high temperature, were investigated at various times by cooling the reacting mixture and titrating any unreacted iodine with sodium thiosulfate.

$$H_2\ (g) + I_2\ (g) \rightarrow HI\ (g)$$

(a) Explain why the reaction mixture was cooled before titrating any unreacted iodine.

_____ (½)

(b) Write an equation which represents the average rate of a reaction in terms of the iodine concentration.

_____

_____ (2)

This question continues on the next page.

(c) In the investigation, at 120 seconds after the start of the reaction, the iodine concentration had fallen from $1x10^{-2}$ moldm^{-3} to 6.00 $x10^{-3}$ moldm^{-3}. What is the average rate of the reaction?

_____

_____ (2)

(d) In the following table mark with a tick, in the appropriate space, how each of the following conditions affects the rate of the above reaction.

Change in condition	Increase the rate	Decrease the rate
Use iodine in the solid state		
Use a higher temperature		
Use lower pressure		

(1½)

(Total: 6 marks)

11. (a) Wine often contains some sulfur dioxide as a preservative. Sulfur dioxide has anti-microbial properties. The amount of added sulfur dioxide can be calculated by reacting a sample of wine with aqueous iodine.

(i) In the reaction, SO_2 is changed to SO_4^{2-} and I_2 is converted to I^-. Write **TWO** half equations which show these changes. Label each half equation as reduction or oxidation.

_____

_____ (2)

(ii) Write a fully balanced equation for the reaction between sulfur dioxide and aqueous iodine.

_____ (1)

(b) A titration showed that the sulfur dioxide in 25.00 cm^3 of a sample of wine reacted exactly with 12 cm^3 of 5.00 $x10^{-3}$ moldm^{-3} aqueous iodine.

(i) How many moles of sulfur dioxide were present in the wine sample?

_____

_____

_____

_____ (1)

(ii) Calculate the concentration in gdm^{-3} of sulfur dioxide in the wine.

_____

_____

_____ (1½)

(iii) The acceptable range of SO_2 in wine is from 0.01 gdm^{-3} to 0.25 gdm^{-3}. Comment on the effectiveness of SO_2 as a preservative in the wine which has been analysed in this case.

_____

_____ (½)

(Total: 6 marks)

12. Ammonia behaves as a weak base in an aqueous solution.

(a) Draw a dot-cross diagram to show the bonding and non-bonding electron pairs in the ammonia molecule.

(½)

(b) Write a balanced equation for the interaction of ammonia with water.

_____ (1)

(c) Explain why ammonia produces an alkaline solution in water.

_____

_____

_____ (1)

(d) Using ammonia as an example, explain the term weak base.

_____

_____ (1)

(e) State whether an aqueous solution of 0.1 $moldm^{-3}$ ammonia has a higher or lower pH than an aqueous solution of 0.1 $moldm^{-3}$ potassium hydroxide. Explain your answer.

_____

_____

_____ (1)

(f) Calculate the pH of 0.1 $moldm^{-3}$ potassium hydroxide. State any assumption you consider.

_____

_____

_____ (1½)

(Total: 6 marks)

13. The structural formula of 1-methoxybutane is

$CH_3 - O - CH_2 - CH_2 - CH_2 - CH_3$

(a) Name the class of compounds of 1-methoxybutane.

_____ (½)

(b) Draw structural isomers of this compound that illustrate:

(i) Positional isomerism

(ii) Hydrocarbon chain isomerism

(iii) Functional group isomerism

(1½)

(c) A compound is composed of 88.9% carbon and 11.1% hydrogen by mass.

(i) What is the empirical formula of the compound?

_____

_____ (1)

(ii) The molar mass of the compound is 54 g. What is the molecular formula of the compound?

_____

_____ (1)

(iii) Draw the structure of, and name all possible isomers of the compound.

(2)

(Total: 6 marks)

SECTION C

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

14. (a) "Many reactions, such as burning fuel, are irreversible … Reversible reactions are different. ... For example … ammonium chloride (a white solid) can break down to form ammonia and hydrogen chloride. It also shows that ammonia and hydrogen chloride (colourless gases) can react to form ammonium chloride again."

http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/chemreac/energychangesrev2.shtml

(i) Outline the difference between a reversible and an irreversible reaction. (4)

(ii) Write a balanced equation for the burning of an alkene in a sufficient supply of oxygen, including state symbols. (2)

(iii) Write the reaction for the decomposition of ammonium chloride, outlined above, including state symbols. (2)

(iv) Explain the meaning of the term 'dynamic equilibrium'. (2)

(b) The Haber Process combines nitrogen (from the air) with hydrogen (mainly from natural gas, methane) into ammonia. The reaction is reversible and the production of ammonia is exothermic.

(i) Write the equation that represents this reaction, including state symbols. (2)

(ii) The value of the ΔH for the production of ammonia is -92 $kJmol^{-1}$. What is the value of ΔH for the decomposition of ammonia back to nitrogen and hydrogen? Explain your answer. (2)

(iii) In an experiment starting with a mixture of hydrogen and nitrogen at 400 ^{o}C, the partial pressures of hydrogen and ammonia at equilibrium were 96 atm and 72 atm respectively. If the value of K_p for this reaction at 400 ^{o}C is 1.83×10^{-4} atm^{-2}, find the partial pressure of nitrogen in the equilibrium mixture. (4)

(iv) Explain what happens if the temperature is raised to 600 ^{o}C. (2)

(Total: 20 marks)

15. (a) Explain each of the following terms:

(i) oxidation and reduction (in terms of electron exchange); (2)

(ii) standard solution. (2)

(b) Calculate the volume of 0.625 $moldm^{-3}$ sodium hydroxide solution needed to neutralise completely 25cm^3 of a 0.5 $moldm^{-3}$ hydrochloric acid solution. (4)

(c) A mass of 3.0 g of a mixture containing iron(II) chloride was shaken with dilute sulfuric acid. The resulting solution required 25.0 cm^3 of 0.02 $moldm^{-3}$ potassium permanganate to oxidise the Fe^{2+} ions in the solution to Fe^{3+} ions. The two half equations involved in this redox reaction are:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

(i) Write the equation for the overall redox reaction. (2)

(ii) Calculate the number of moles of permanganate used in the reaction. (3)

(iii) Calculate the number of moles of Fe^{2+} ions involved in the reaction. (2)

(iv) Calculate the mass of iron(II) chloride present. (3)

(v) Calculate the percentage (by mass) of iron(II) chloride in the mixture. Give your answer to two places of decimal. (2)

(Total: 20 marks)

16. (a) Consider the following table with the values of the enthalpy change of combustion of carbon, hydrogen and benzene respectively.

	$\Delta H°_c$ (kJmol^{-1})
C(s)	-394
$H_2(g)$	-286
$C_6H_6(l)$	-3267

(i) Write the equations corresponding to the enthalpy change of combustion of carbon, hydrogen and benzene respectively. (3)

(ii) Write the equation corresponding to the enthalpy change of formation of benzene. (1)

(iii) Draw a Hess' cycle that joins the four chemical equations needed to calculate the enthalpy of formation of benzene. (4)

(iv) Calculate the enthalpy of formation of benzene. (4)

(b) Ethane reacts with chlorine to give chloroethane and hydrogen chloride. All reactants and products are gases. The table below gives the relevant bond enthalpy terms of the bonds involved in this reaction.

Bond	Bond enthalpy term (kJmol^{-1})
C – H	413
Cl – Cl	243
C – Cl	346
H – Cl	432

(i) Write the chemical equation for the reaction between ethane with chlorine. (1)

(ii) Write the chemical equation for the reaction between ethane and chlorine using structural formulae. (2)

(iii) Calculate the enthalpy change of the reaction between ethane and chlorine. (5)

(Total: 20 marks)

17. Explain each of the following statements, illustrating your answer with suitable examples.

(a) There are aliphatic and aromatic hydrocarbons. (4)

(b) Benzene and aromatic hydrocarbons have a stable delocalised structure. (4)

(c) There are alkanes, alkenes and alkynes; some undergo substitution reactions while others undergo addition reactions. (6)

(d) Markownikov's Rule predicts the position of X in the addition of HX to unsymmetrical alkenes. (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															

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