Index Number:_____ IM06.19s

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2019 SECOND SESSION

SUBJECT:	**Chemistry**
DATE:	5th September 2019
TIME:	9:00 a.m. to 12:05 p.m.

Useful information

Molar gas constant R = 8.31 $Jmol^{-1}K^{-1}$
Relative atomic masses: C =12, O = 16, Fe = 56, Cu = 63.5
A Periodic Table is included.

SECTION A

Answer ALL questions in this section.

1. (a) An alkene has three carbon atoms. Draw the structural formula of this alkene and give its name.

_____ (1)

(b) (i) This alkene reacts with hydrogen bromide. Give the structural formula of the product.

(1)

(ii) Fill the blanks in the following statement:

The reaction between the alkene and hydrogen bromide is an _____ reaction, and the product is obtained according to _____ rule. (1)

(Total: 3 marks)

2. Consider the reaction: CH_4 (g) + Cl_2 (g) ⟶ CH_3Cl (g) + HCl (g)
Take into consideration the following bond enthalpy terms: [C – H] = 413 $kJmol^{-1}$; [Cl – Cl] = 243 $kJmol^{-1}$; [C – Cl] = 346 $kJmol^{-1}$; [H – Cl] = 432 $kJmol^{-1}$

(a) Find the total energy involved in bond breaking.

_____

_____ (1)

(b) Find the total energy change involved in bond formation.

_____

_____ (1)

(c) Work out the enthalpy of reaction.

_____

_____ (1)

(Total: 3 marks)

3. A sample of gas is at a pressure of 101,000 Pa and occupies a volume of 12.35 x 10^{-3} m^3 at a temperature of 27 ^{O}C.

(a) Find the number of moles of gas present in the sample.

_____

_____

_____ (2)

(b) Find the relative molecular mass of the gas if the mass of the sample is 14 g.

_____

_____ (1)

(c) If the gas is an oxide of carbon, deduce the molecular formula for this gas. Show your reasoning.

_____

_____ (1)

(Total: 4 marks)

4. Consider the stable isotope of sodium $^{23}_{11}Na$.

(a) Define the term isotope.

_____

_____ (1)

(b) For $^{23}_{11}Na$, fill in the blanks: atomic number: _____ mass number: _____ number of protons: _____ number of neutrons: _____ (2)

(c) Another isotope of sodium is $^{24}_{11}Na$. It decays by β-emission. Write the nuclear equation that shows this decay. Use the Periodic Table to deduce the symbol of the product.

_____ (1)

(Total: 4 marks)

5. The octet rule can be used in order to predict formulae of compounds. There are exceptions to the octet rule, as in the case of $AlCl_3$ and PCl_5.
   (a) What is the octet rule?

_____

_____

_____ (1)

   (b) Why is $AlCl_3$ an exception to the octet rule? You may include dot-and-cross diagrams in your answer.

_____

_____

_____ (1)

   (c) Why is PCl_5 an exception to the octet rule? You may include a dot-and-cross diagrams in your answer.

_____

_____

_____ (1)

   (d) Why is $AlCl_3$ an exception to the octet rule, while PCl_3 is not? You may include a dot-and-cross diagrams in your answer.

_____

_____

_____ (1)

(Total: 4 marks)

6. (a) Difunctional molecules can form polymers by condensation reactions. Explain each of the following terms:

   (i) Difunctional molecules: _____

_____ (½)

   (ii) Polymer: _____

_____ (1)

   (iii) Condensation reaction: _____

_____ (1)

This question continues on the next page.

(b) Polyesters are condensation polymers formed from difunctional molecules. Molecule A and molecule B below can form a condensation polymer.
Explain, giving a chemical equation where necessary.

Molecule A: HOOC—[ ]—COOH Molecule B: HO—[ ]—OH

_____

_____

_____

_____ (1½)

(Total: 4 marks)

7. (a) A solution of reagent X reacts with a solution of reagent Y to give products Z and D. This is not a reversible reaction.
Indicate whether the rate of reaction will increase, decrease or would not vary for each of the changes indicated below. Mark X in the appropriate box.

Change	Increase in rate	Decrease in rate	Rate does not vary
Increasing the concentration of solution X			
Increasing the mass of product Z			
Increasing the temperature			
Introducing an appropriate catalyst			

(2)

(b) Solid reagent A reacts with a gaseous reagent J in a closed container to give products E and G.
Indicate whether the rate of reaction will increase, decrease or would not vary for each of the changes indicated below. Mark X in the appropriate box.

Change	Increase in rate	Decrease in rate	Rate does not vary
Having solid A in bigger pieces			
Increasing the volume of the container			
Increasing the pressure of the gas in the container			
Putting the container upside down			

(2)

(Total: 4 marks)

8. (a) Give the oxidation state of Mn in each of the following. Show your reasoning wherever necessary.

Mn^{2+}: _____

MnO_2: _____

MnO_4^{2-}: _____

MnO_4^-:_____ (2)

(b) Give the colour of a solution containing each of the following ions:

Fe^{2+} _____ Fe^{3+} _____

Cu^+ _____ Cu^{2+} _____ (2)

(Total: 4 marks)

SECTION B

Answer ALL questions in this section.

9. (a) Benzene can undergo both substitution and addition reactions. Indicate which type of reaction is easier to take place, and explain why.

_____

_____ (2)

(b) Benzene undergoes a number of substitution reactions. In each case below, write the chemical equation, including any conditions and catalysts.

(i) The reaction of benzene with chlorine.

_____

_____ (2)

(ii) The substitution reaction of benzene with sulfuric (VI) acid.

_____

_____ (2)

(Total: 6 marks)

10. (a) Fill in the blanks in the short paragraph below:

A mole is a unit of measurement. A mole is the quantity of anything that has the same number of particles found in _____ grammes of ^{12}C. That number of particles is called the _____ number , and is roughly equal to 6.02 x _____. A mass of 8 g of oxygen atoms would contain _____ atoms. (2)

(b) A strip of iron of mass 0.56 g was immersed in 25 cm^3 of 0.5 $moldm^{-3}$ hydrochloric acid solution.

(i) Write the chemical equation, including state symbols, for the reaction between iron and hydrochloric acid.

_____ (1)

(ii) Find the number of moles of iron.

_____

_____ (1)

(iii) Find the number of moles of H^+ (aq) in the hydrochloric acid solution.

_____

_____ (1)

(iv) Give the number of moles of gas produced. Show your reasoning.

_____

_____ (1)

(Total: 6 marks)

11. (a) A rod of silver and a rod of aluminium are successively placed in a solution of dilute acid. Explain what will be observed in terms of their position in the electrochemical series. Write ionic equations (including state symbols) where necessary.

_____

_____

_____

_____

_____

_____ (3)

(b) A student was investigating the redox properties of magnesium and zinc. So, she immersed a piece of magnesium ribbon in a solution containing zinc ions in beaker A, and a zinc rod in a solution containing magnesium ions in beaker B.
Explain in terms of oxidation and reduction, the observations in beaker A and beaker B. Include half equations where necessary.

_____

_____

_____

_____

_____

_____ (3)

(Total: 6 marks)

12. (a) Let us consider the elements in the second period of the Periodic Table.
Use the Periodic Table, and write down the first **FOUR** elements of period 2, and their corresponding electronic configurations (in spdf notation) in the table below.

Element				
Electronic configuration				

(2)

(b) (i) Explain the term periodicity.

_____

_____ (1)

(ii) How does the valency vary across the period?

_____ (1)

(iii) How does the melting point vary across the whole period?

_____

_____ (1)

(iv) How does the atomic radius vary across the whole period?

_____

_____ (1)

(Total: 6 marks)

13. (a) The equilibrium reaction between ethanol and ethanoic acid gives an ester and water. This is a homogeneous equilibrium reaction.

(i) Explain what is homogeneous equilibrium.

_____ (1)

(ii) Write the equation that represents this equilibrium reaction, including state symbols.

_____ (1½)

(iii) The equilibrium reaction is actually very slow. Indicate a catalyst that can speed up this equilibrium reaction.

_____ (½)

(b) Consider the following homogeneous equilibrium reaction:

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

(i) Write the equation for K_P for this equilibrium reaction, and indicate its units.

_____

_____ (1)

(ii) Find K_P if the partial pressures of SO_2, O_2 and SO_3 at equilibrium are 0.165 atm, 0.757 atm and 0.084 atm respectively.

_____

_____

_____

_____

_____ (2)

(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. (a) (i) Write an equation for the reaction that occurs when ammonia is dissolved in water. (1)
    (ii) A weak base is said to have a strong conjugate acid. Refer to the above reaction [in part (a)(i)] and explain this statement. (2)
    (b) The base dissociation constant K_b may be used to distinguish strong bases from weak bases.
    (i) Write an expression for K_b for ammonia and state its units. (2)
    (ii) Explain why the weaker the base, the lower its K_b value. (2)
    (c) Both ammonia and ethanamine are weak bases. The value of K_b at 298 K for ammonia is 1.75×10^{-5} moldm^{-3} and the value of K_b for ethanamine at the same temperature is 4.3×10^{-4} moldm^{-3}.
    (i) Which of the two bases is the weaker base? (1)
    (ii) Discuss the following statement: The K_b value of ammonia is a constant for reactions in some conditions but it does change with a change in one particular condition. (1)
    (d) K_w is another equilibrium constant known as the ionic product of water.
    (i) Write an expression for K_w. (1)
    (ii) K_w applies for neutral, acidic and alkaline solutions. Explain this statement. (3)
    (iii) K_w has a value of 1×10^{-14} mol^{2}dm^{-6} at 298 K. What is the concentration of hydronium (H^+) ions in a solution where the hydroxide (OH^-) ion concentration is 5.8×10^{-6} moldm^{-3}? (2)
    (e) A student wanted to find the pH of a solution of sulfuric (VI) acid of unknown concentration. The student titrated samples of the acid with a standard solution of potassium hydroxide of concentration 0.500 moldm^{-3}. It was found that 25.00 cm^3 of the acid reacted with 35.50 cm^3 of the potassium hydroxide solution.
    (i) Calculate the concentration of the sulfuric (VI) acid. (3)
    (ii) Calculate the pH of the sulfuric (VI) acid solution to two decimal places. (2)

(Total: 20 marks)

15. (a) State and explain the trends in:
    (i) the boiling points of the halogens Cl_2, Br_2 and I_2; (3)
    (ii) the electronegativity of the halogens from fluorine to iodine; (3)
    (iii) the oxidising strength of the halogens from chlorine to iodine; (3)
    (iv) the acidity of HCl, HBr and HI. (3)
    (b) Hydrogen chloride can be prepared by reacting concentrated sulfuric (VI) acid with sodium chloride, but hydrogen bromide cannot be prepared from the reaction of concentrated sulfuric (VI) acid with sodium bromide.
    (i) Write a balanced equation for the reaction of sulfuric (VI) acid with sodium chloride. (2)
    (ii) Explain why concentrated sulfuric (VI) acid and sodium bromide are not used to prepare hydrogen bromide. (3)
    (iii) Which acid may be used to prepare hydrogen bromide from sodium bromide? (1)
    (iv) Write a balanced equation for the preparation of hydrogen iodide from an appropriate acid and sodium iodide. (2)

(Total: 20 marks)

16. (a) P and Q are organic compounds containing four carbon atoms and are functional group isomers. A set of experiments were performed on compounds P and Q.
    - In a reaction, compound P was reduced to compound R, which reacted with phosphorus pentachloride to produce one mole of hydrogen chloride.
    - In another reaction, compound P, unlike its functional group isomer Q, did not react with Fehling's solution.
    - In another experiment, compound Q was reduced to compound S, which reacted with phosphorus pentachloride to produce one mole of hydrogen chloride.
    - In separate reactions both compound Q and compound S were oxidised to a compound T, which reacted with phosphorus pentachloride.
    - In another reacting vessel, compound Q was treated with hydrogen cyanide and produced a product U. When warm acid was added to the product U, a compound W containing two functional groups was formed.

    (i) Give the definition of functional group isomers. (1)
    (ii) Name and draw the structure of compound P and compound R. (2)
    (iii) Name the reagent and conditions which are used to reduce compound P to compound R. (2)
    (iv) Compound Q reacts with Fehling's solution. Name compound Q. (1)
    (v) Describe what will be observed when Q reacts with Fehling's solution. (2)
    (vi) Name compound S and compound T. (2)
    (vii) Write a balanced equation for the reaction of T with phosphorus pentachloride. (1)
    (viii) Write the **TWO** functional groups which are present in compound W. (1)
    (ix) Define positional isomerism. (1)
    (x) Identify **TWO** compounds from P, Q, R and S which are positional isomers. (1)

(b) In an aromatic reaction, benzene was converted to compound X. Compound X was used to synthesise an aromatic compound Y with an amine group.

    (i) Draw the structure of compound X and compound Y. (2)
    (ii) Name the reagents and the conditions which were used in the formation of compound X from benzene. (2)
    (iii) Name the reagents and write the conditions which are used for the synthesis of compound Y from compound X. (2)

(Total: 20 marks)

This Section continues on the next page. There is another question.

17. (a) In an attempt to identify the different metal ions in three nitrate (V) salts A, B and C, a student performed some tests with different reagents. In the first run of tests, a few drops of sodium hydroxide solution were added to each of around 1 cm^3 solution of the three salts in separate test-tubes.
- Salt A gave a green gelatinous precipitate which slowly turned to brown.
- Salt B gave a green precipitate which dissolved after the addition of more sodium hydroxide solution.
- Salt C gave a pale blue precipitate.

In a second run of tests, aqueous ammonia was used as a reagent.
- Salt A gave a green gelatinous precipitate which slowly turned to brown.
- Salt B gave a green precipitate which did not dissolve in excess ammonia solution.
- Salt C gave a pale blue precipitate which dissolved in excess ammonia solution to give a deep blue solution.

(i) Identify the different cations in the salts A, B and C. (3)

(ii) Write the ionic equation for the reaction of the cation in salt A with aqueous sodium hydroxide, which resulted in the green precipitate. (2)

(iii) Explain why the green precipitate turned brown on standing. (1)

(iv) The deep blue solution contained a soluble metal complex cation. Write the formula of this complex cation and underline the ligand in this complex. (2)

(v) Describe the bonding which is present in the complex in part (iv). (2)

(vi) The student wanted to confirm that the anion in the salts A, B and C was nitrate (V). Describe the tests and results that would confirm the presence of the nitrate (V) anion. (3)

(b) Brass is an alloy of copper and zinc. A metallurgist analysed a small piece of brass to determine the percentage of copper in the brass. An excess of nitric (V) acid was added to the brass, which weighed 0.35 g. The copper and zinc atoms in the brass formed Cu^{2+} and Zn^{2+} cations in the solution. An excess of aqueous potassium iodide was added to the solution. The Cu^{2+} cations in the solution reacted with the iodide ions. The iodine which was released in this reaction required 20.60 cm^3 of 0.200 $moldm^{-3}$ of sodium thiosulfate solution.

$$2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow 2CuI(s) + I_2(aq)$$

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

(i) Calculate the number of moles of iodine which were released, when the iodide solution was added to the copper ion solution. (2)

(ii) Calculate the number of moles of copper ions which were present in the solution. (2)

(iii) Calculate the percentage of copper in the brass. (3)

(Total: 20 marks)

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PERIODIC TABLE

Key

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

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