NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

InSTEM

QUALIFICATION: INTRODUCTION TO SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS	
QUALIFICATION CODE: 04STEM	**LEVEL:** 4
COURSE CODE: ICH401S	**COURSE NAME:** INTRODUCTION TO CHEMISTRY A
SESSION: JANUARY 2020	**PAPER:** N/A
DURATION: 3 HOURS	**MARKS:** 100

SECOND OPPORTUNITY EXAMINATION QUESTION PAPER	
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MODERATOR:	**Prof Habauka M Kwaambwa**

INSTRUCTIONS
1. Answer all questions. 2. Write all the answers in ink. 3. No books, notes, correction fluid (Tippex) or cell phones allowed. 4. Pocket calculators are allowed. 5. You are not allowed to borrow or lend any equipment or stationary. 6. All **FINAL ANSWERS** must be rounded off to **TWO DECIMAL PLACES** unless otherwise stated. 7. Periodic table on page 10.

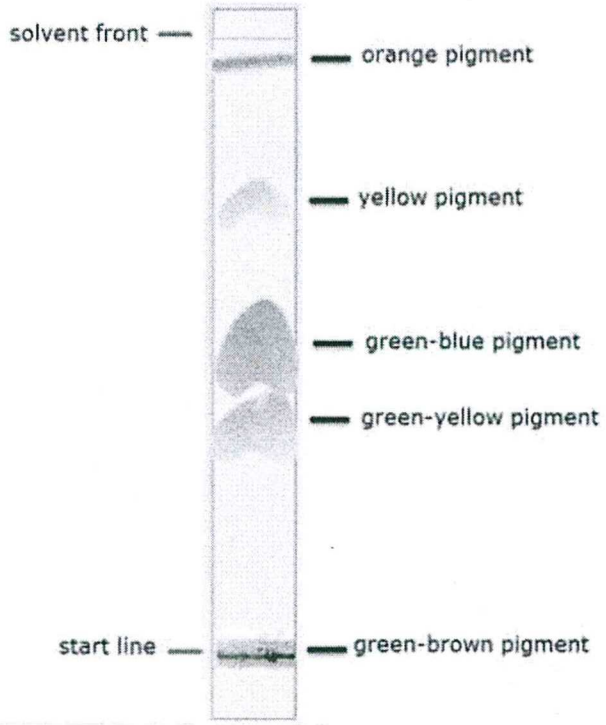
THIS QUESTION PAPER CONSISTS OF 10 PAGES (Excluding this front page)

Question 1 **[9]**

1.1 Name the techniques, which are suitable for separating the following mixture: (3)

Situation	Separation Technique
Petrol from crude oil	
Pure sugar from a solution	
Two immiscible liquids	

1.2 The diagram below shows the chromatography paper from an experiment that has been analysed and four pigments identified. The centre of each pigment is marked and the colour labelled.



1.2.1 Find the R_f value for each pigment on the diagram: (4)

Orange
Yellow
Green-Blue
Green-Yellow

1.2.2 The table below shows Reference R_f values:

Pigment	R_f Value
Carotene	0.94
Xanthopll	0.89
Chlorophy A	0.46
Chlorophyl B	9.22

Identify the four pigments as best you can using the reference Rf values. (2)

Question 2 **[11]**

Titanium and vanadium are consecutive elements in the first transition metal series.

2.1 Describe the bonding in metals. (1)

2.2 Titanium exists as several isotopes. The mass spectrum of a sample of titanium gave the following data:

Mass number	% abundance
46	7.98
47	7.32
48	73.99
49	5.46
50	5.25

Calculate the relative atomic mass of titanium to two decimal places. (2)

2.3 State the number of protons, neutrons and electrons in the $^{48}_{22}Ti$ atom. (1)

2.4.1 State the full electron configuration of the $^{48}_{22}Ti^{2+}$ ion. (3)

2.4.2 Suggest why the melting point of vanadium is higher than that of titanium. (1)

2.4.3 Vanadium and titanium can form metal complexes with ligands. Describe, in terms of the electrons involved, how the bond between a ligand and a central metal ion is formed. (1)

2.5.1 State the type of bonding in potassium chloride, which melts at 1043 K. (1)

2.5.2 A chloride of titanium, $TiCl_4$, melts at 248 K. Suggest why the melting point is so much lower than that of KCl. (1)

Question 3 **[11]**

Hydrogen sulfide, given off by decaying organic matter, is converted to sulfur dioxide in the atmosphere by the reaction:

$$2H_2S(g) + 3O_2(g) \rightarrow 2SO_2(g) + 2H_2O(l)$$

3.1 How many moles of H_2S are required to form 8.20 moles of SO_2? (1)

3.2 How many grams of O_2 are required to react with 1.00 mole of H_2S? (2)

3.3 How many grams of water are produced from 6.82 g H_2S? (2)

3.4 If 12.0 grams of SO_2 are formed from 7.98 g of H_2S, what is the percent yield? (3)

3.5 How many grams of SO_2 are produced starting from 2.66 g H_2S and 3.00 g O_2? Which reactant is the limiting reagent? (3)

Question 4 **[6]**

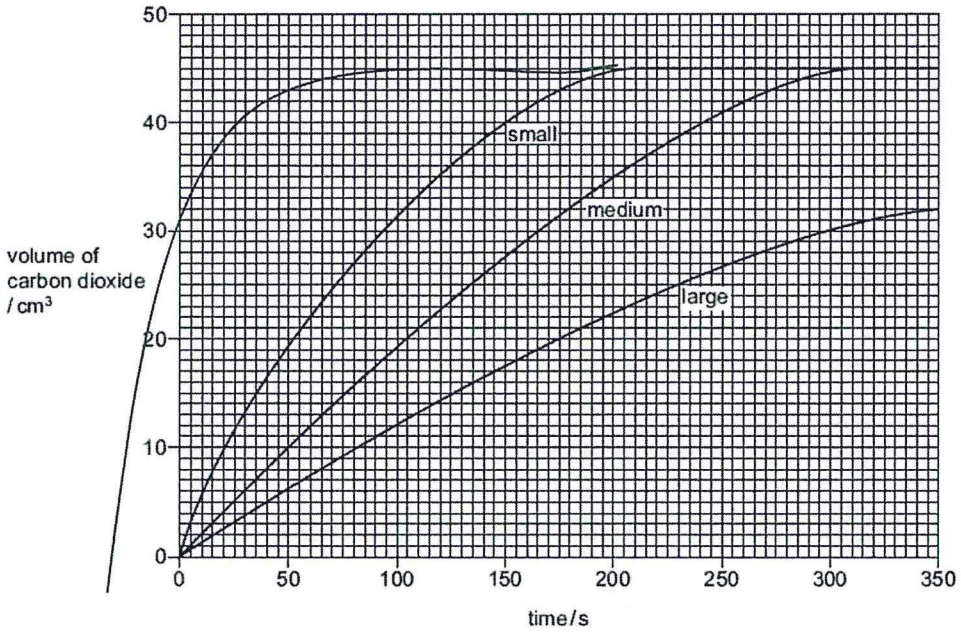
Calcium carbonate reacts with dilute hydrochloric acid:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

A student investigated this reaction by measuring the volume of carbon dioxide released every minute at constant temperature.

4.1 Draw a diagram of the apparatus that the student could use to investigate this reaction. (2)

4.2 The graph shows the results of this reaction using three samples of calcium carbonate of the same mass: large pieces, medium-sized pieces and small pieces.



4.2.1 Which sample, large, medium or small pieces, gave the fastest initial rate of reaction? (1)

4.2.2 The experiment was repeated using powdered calcium carbonate of the same mass. Draw a line **on the grid above** to show how the volume of carbon dioxide changes with time for this experiment. (2)

4.2.3 At what time was the reaction just complete when small pieces of calcium carbonate were used? (1)

Question 5 **[9]**

5.1 The table below shows the boiling points of some hydrogen compounds formed by Group 6 elements:

	H_2O	H_2S	H_2Se	H_2Te
Boiling point/K	373	212	232	271

State the strongest type of intermolecular force in water and in hydrogen sulphide (H_2S). (2)

5.2 Draw a diagram to show how two molecules of water are attracted to each other by the type of intermolecular force you stated in part (5.1). Include partial charges and all lone pairs of electrons in your diagram. (3)

5.3 Explain why the boiling point of water is much higher than the boiling point of hydrogen sulphide. (1)

5.4 When H^+ ions react with H_2O molecules, H_3O^+ ions are formed. Name the type of bond formed when H^+ ions react with H_2O molecules. Explain how this type of bond is formed in the H_3O^+ ion. (3)

Question 6 **[17]**

Lewis (electron dot) structures are useful models.

6.1 Draw the Lewis (electron dot) structures of PF_3 and use the VSEPR theory to deduce the molecular geometry including bond angles. (3)

6.2 Predict whether the molecules PF_3 and PF_5 are polar or non-polar. (1)

6.3 The table below gives the values of the first three ionisation energies of magnesium:

	First ionisation energy	Second ionisation energy	Third ionisation energy
Ionisation energy/kJmol^{-1}	738	1451	7733

6.3.1 Write an equation to illustrate the process occurring when the first ionization energy of magnesium is measured (1)

6.3.2 Explain why the third ionisation energy of magnesium is very much larger than the second ionisation energy of magnesium. (2)

6.3.3 State and explain the trend in the first ionisation energy of the elements Mg to Ba in Group II. (3)

6.3.4 There is a trend in the reactivity of the Group II metals with H_2O. State the conditions needed for Mg and Ca to react rapidly with H_2O. Write an equation for each of these reactions. (4)

6.3.5 Explain why Aluminium do not fit the expected trends of first ionisation energies of period 3. (3)

Question 7 **[9]**

7.1 Draw a graph to show a Maxwell–Boltzmann distribution of molecular energies for a gas. Label the axes. On the same axes draw a second curve to show the distribution for the gas at a higher temperature. Label this second curve W. (5)

7.2 A reaction of nitrogen monoxide is shown below:

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The rate of reaction can be found by measuring the concentration of NO_2 at different times. Define the term **rate of reaction**. Draw a graph to show how the concentration of NO_2 changes with time. Indicate how the initial rate of reaction could be obtained from your graph. (4)

Question 8 **[10]**

8.1 Define the term standard enthalpy change of formation, $\Delta H^{\emptyset}_f$. (1)

8.2 Define the term average bond enthalpy. (1)

8.3 Consider the following equations:

$3A + 6B \rightarrow 3D \quad \Delta H = -403$ kJ/mol
$E + 2F \rightarrow A \quad \Delta H = -105.2$ kJ/mol
$C \rightarrow E + 3D \quad \Delta H = +64.8$ kJ/mol

Suppose the first equation is reversed and multiplied by 1/6, the second and third equations are divided by 2, and the three adjusted equations are added. What is the net reaction and what is the overall heat of this reaction? (4)

8.4 Calculate ΔH for the reaction: **C_2H_4 (g) + H_2 (g) → C_2H_6 (g)**, from the following data:

C_2H_4 (g) + $3O_2$ (g) → $2CO_2$ (g) + $2H_2O$ (l) $\Delta H = -1411.$ kJ
C_2H_6 (g) + $3½\ O_2$ (g) → $2\ CO_2$ (g) + $3H_2O$ (l) $\Delta H = -1560.$ kJ
H_2 (g) + $½\ O_2$ (g) → H_2O (l) $\Delta H = -285.8$ kJ (4)

Question 9 **[12]**

9.1 Describe how aluminium is manufactured from purified bauxite. Illustrate your answer by writing equations. (5)

9.2 Reducing agents are used in the extraction of metals.

9.2.1 In terms of electrons, state the function of a reducing agent. (1)

9.2.2 Identify a reducing agent used in the extraction of iron. Write an equation for the redox reaction in which iron is formed from iron (III) oxide using this reducing agent. (2)

9.2.3 The iron formed in the blast furnace is impure. It contains about 5% of carbon and other impurities, such as silicon and phosphorus. Describe how the percentage of carbon is reduced and the other impurities are removed. (4)

Question 10 **[6]**

Tin (II) ions can be oxidised to tin (IV) ions by acidified potassium permanganate (VII) solutions according to the following unbalanced equation:

$Sn^{2+} + MnO^4 + H^+ \rightarrow Sn^{4+} + Mn^{2+} H_2O$

10.1 Identify the oxidising agent and the reducing agent from the equation above. (2)

10.2 Balance the equation above. (3)

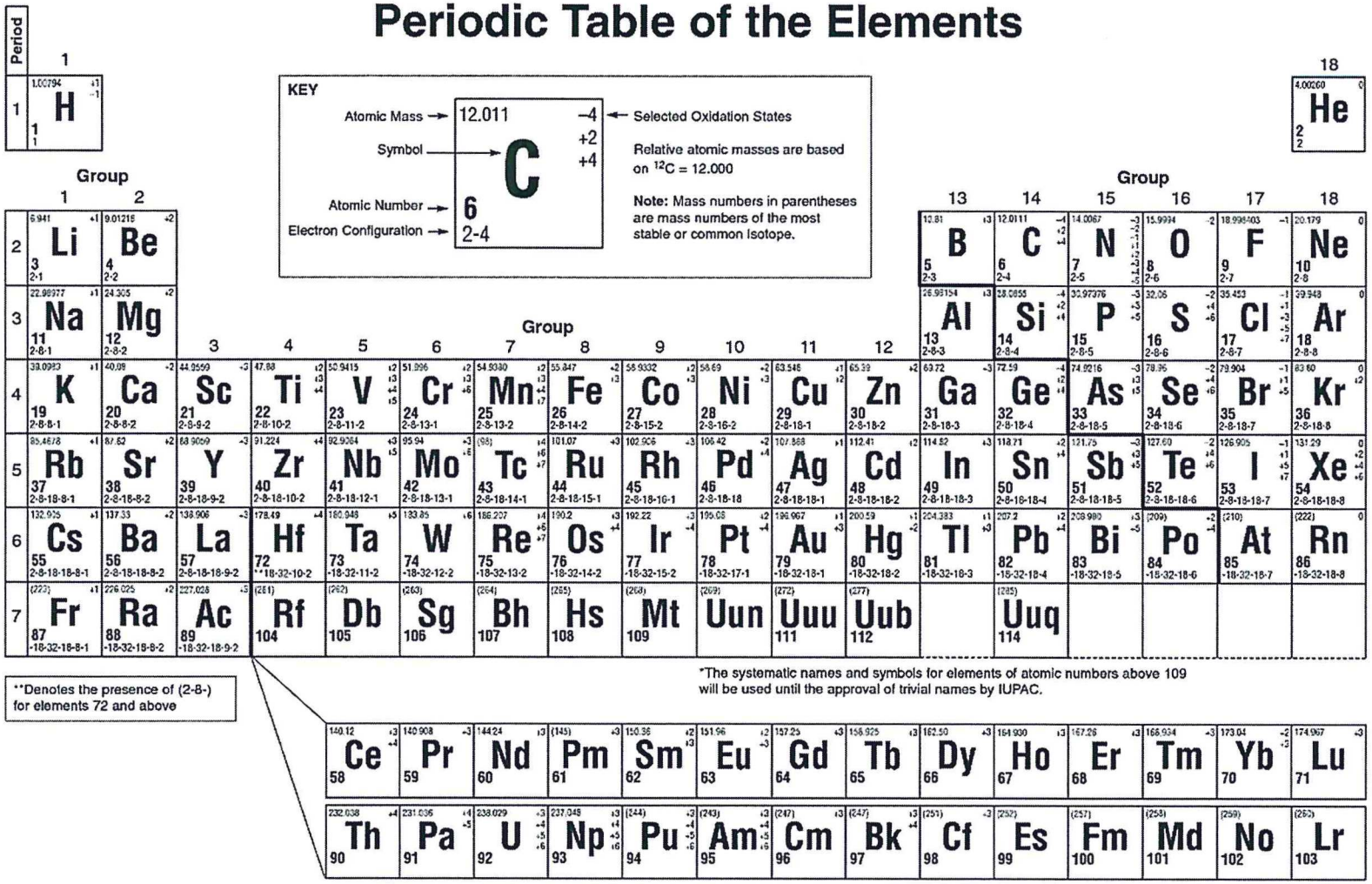
10.3 Consider the following redox equation:

$5Fe^{2+}_{(aq)} + MnO^-_{4(aq)} + 8H^+_{(aq)} + \rightarrow 5Fe^{2+}_{(aq)} + Mn^{2+}_{(aq)} + 4H_2O_{(l)}$

Determine the oxidation numbers for Mn in the reactants. (1)

THE END

Periodic Table of the Elements



**Denotes the presence of (2-8-) for elements 72 and above

*The systematic names and symbols for elements of atomic numbers above 109 will be used until the approval of trivial names by IUPAC.

Reference Tables for Physical Setting/CHEMISTRY