QUESTION ONE (INTRODUCTION TO GENERAL CHEMISTRY) [25 marks]

a) Define each of the following terms applied in the scientific method:
   (i) Hypothesis (ii) theory (iii) law [3]

b) Use exponential notation to express the number 101.325 to:
   (i) One significant figure. [1]
   (ii) Five significant figures. [1]

c) State the difference between precision and accuracy. [2]

d) Perform the following mathematical operations, and express each result to the correct number of significant figures.
   (i) $(9.04 - 8.23) + 21.954 + 81.0) \div 3.1416$ [2]
   (ii) $\frac{0.470}{0.623} + \frac{80.705}{0.4326} - \frac{2.526}{3.1}$ [2]

e) Show your understanding of metric prefixes by giving the name to the unit that equals the following:
   (i) 10^{-9} gram (ii) 10^{+9} gram (iii) 10^{-15} metre [3]

f) Convert each of the following temperatures from degrees Celsius to Kelvin:
   (i) –38.9 °C (ii) 119.3 °C [4]

g) State the chemical formula of each of the following compounds:
   (i) Perchloric acid (ii) Phosphorus pentachloride [4]

h) Europium has two isotopes whose relative abundances are 48 % and 52 %. Given that the average atomic mass of Europium is 151.96 amu and the mass of an isotope with relative abundance of 52 % is 152.92 amu. Determine the mass of the isotope whose relative abundance is 48%. [3]

QUESTION ONE (Introduction and Atomic Structure) [20 marks]

a) An automobile runs for 10 minutes and burns 47 g of gasoline. The gasoline combined with oxygen from air and formed 132 g of carbon dioxide and 34 g of water. How much oxygen was consumed in the process? Name the law applied to solve above problem? [3]

b) Gallium has two naturally occurring isotopes: Ga-69 with mass 68.9256 amu and a natural abundance of 60.11%, and Ga-71 with mass 70.9247 amu and a natural abundance of 39.89%. Calculate the atomic mass of gallium. [3]

c) How many protons, neutrons, and electrons are in:

i) $^{41}_{20}R$

ii) $^{131}_{53}S$

iii) What element symbol do R and S represent? [4]

d) Calculate the wavelength (in nm) and the wave number of red light emitted by a barcode scanner that has a frequency of $4.62 \times 10^{14}\ s^{-1}$. [3]

e) Write a set of four quantum numbers for the eighth electron of the Cl atom. [2]

f) Given the following systematic names, write the formula for each compound: [5]

i) Sodium hydrogen carbonate $NaHCO_3$

ii) Cesium perchlorate

iii) Sodium hypochlorite

iv) Sodium selenate

v) Barium hydroxide octahydrate

moles c. v
0.15 moles

[25 MARKS]

QUESTION 1: INTRODUCTION

[5]

a) Fill each blank space with an appropriate word in the sentences that follow;

Energy is a by-product of many chemical processes.

When considering nuclear energy, _____ [i] is a proven large scale energy source but has radioactive waste problems. _____ [ii] can help to devise better ways of disposing nuclear waste.

Energy production and energy utilization can negatively affect our environment. For example, burning fossil fuels gives off _____ [iii] which is a greenhouse gas along with _____ [iv] and _____ [v] which result in acid rain. However, new technologies are being introduced to reduce harmful emissions and improve air quality.

[6]

b) Fill in the Table below for units of measurements.

Table 1: Table of Units of Measurement

	Base Quantity	Name of Unit	Symbol
1	Mass	Kilogram	kg
2			
3			
4			
5			
6			
7			

c) What is the collective term used for the units in question (b)? [1]

d) In Table 1, correctly list the three parameters that uniquely identify an isotope in the nuclide symbol ${}^{A}_{Z}X$. [3]

Table 2: Parameters that uniquely describe an isotope

Parameter	Meaning of parameter
A	
X	
Z	

e) For a nuclide, two of its components give the same value. Which are these two? [1]

f) A certain isotope X^{+} contains 54 electrons and 78 neutrons. Write the nuclide of this isotope. [3]

g) Complete the table below on the three fundamental chemical laws that you learnt in the introductory topic of General Chemistry. [6]

Table 3: List of three Fundamental Chemical Laws

No.	Name of Fundamental Chemical Law	Discoverer of Law
1		
2		
3		

QUESTION 1: INTRODUCTION TO CHEMISTRY & CHEMICAL EQUILIBRIA

[20 Marks]

a) Describe how the equilibrium constant for an overall reaction is related to the equilibrium constants for the individual reactions that yield the overall reaction. [2]

b) What role does a catalyst play in a reversible chemical reaction? How does a catalyst affect the value of the equilibrium constant for a reaction? [2]

c) A closed system initially containing 1.0×10^{-3} M H_2 and 2.0×10^{-3} M I_2 at 448 °C is allowed to reach equilibrium. Analysis of the equilibrium mixture shows that the concentration of HI is 1.87×10^{-3} M.

i) Write a balanced chemical equation with state symbols for the above reaction [1]

ii) Calculate K_c at 448 °C for the reaction taking place. [6]

d) Fill each blank space with an appropriate word in the sentences that follow.

i) _____ is a set of tested hypotheses that gives an overall explanation of natural phenomenon [1]

ii) _____ is a summary of repeatable measurable behavior. [1]

iii) _____ is a possible explanation for an observation. [1]

e) As a group, what do the above statements in (d) compose of? [2]

f) Complete the names of the anions and acids whose chemical formulae are given in the table below. [4]

Table 1: Names of anions and acids

No.	Acid's chemical formula	Acid's anion	Acid's name
1	H_2S		
2	$HClO_2$		
3	$HBrO_3$		
4	HIO_4		

QUESTION 1: INTRODUCTION

[25 MARKS]

a) Fill each blank space with an appropriate word in the sentences that follow. [3]

(i) _____ is a set of tested hypotheses that gives an overall explanation of natural phenomenon [1]

(ii) _____ is a summary of repeatable measurable behavior. [1]

(iii) _____ is a possible explanation for an observation. [1]

b) As a group, what do the above statements compose of? [2]

c) Complete the names of the anions and acids of the acids whose chemical formulae are given in the table below. [4]

Table 1: Names of anions and their acids

No.	Acid's chemical formula	Acid's anion	Acid's name
1	H_2S		
2	$HClO_2$		
3	$HBrO_3$		
4	HIO_4		

d) Fill in the blank spaces using a word for each space [6]

(i) _____ is the estimate in a measurement that depends on the precision of the measuring device. [1]

(ii) The term _____ is agreement of a particular value with a true value. [1]

(iii) _____ is the degree of agreement among several measurements of the same quantity. [1]

(iv) These terms are encountered when doing the opposite of qualitative observations, that is, _____ observations which have two parts, namely, _____ and _____. [3]

e) Mixtures have variable compositions. Using two very short sentences of less than 10 words, distinguish a homogeneous mixture from a heterogeneous mixture. [2]

f) Which of the listed substances is a homogeneous mixture? [2]

(i) Pure water
(ii) Clean air
(iii) Petrol
(iv) Soil
(v) Copper wire

g) Complete the table below on the three fundamental chemical laws that you learnt in the introductory topic of General Chemistry. [6]

Table 2: List of three Fundamental Chemical Laws

No.	Fundamental Chemical Law's	
	Name	Definition
1		
2		
3		

QUESTION 1: INTRODUCTION & ATOMIC STRUCTURE [20 MARKS]

a) Does each of the following describe a physical change or a chemical change? [3]

i. The helium gas inside a balloon tends to leak out after a few hours.

ii. A flashlight beam slowly gets dimmer and finally goes out.

iii. Frozen orange juice is reconstituted by adding water to it.

b) Express the following numbers as decimals: [2]

(i) 1.52×10^{-2} (ii) 7.78×10^{-8}

c) How many significant figures are there in each of the following? [3]

(i) 0.006 L (ii) 0.0605 dm^3 (iii) 60.5 mg

d) Venus, the second closest planet to the sun, has a surface temperature of 7.3×10^2 K. Convert this temperature to °C and °F. [2]

e) Give the maximum number of electrons in an atom that can have the following quantum numbers: [3]

(i) n = 4 (ii) n = 5, $m_l = +1$ (iii) n = 5, $m_s = +\frac{1}{2}$

f) Give a possible set of values of the four quantum numbers for all the electrons in a boron atom and a nitrogen atom if each is in the ground state. [5]

g) For each of the following pairs of elements [2]

(C and N) (Ar and Br) pick the atom with

i. more favorable (exothermic) electron affinity.

ii. higher ionization energy.

QUESTION 1: INTRODUCTION & ATOMIC STRUCTURE AND PERIODICITY [20 Marks]

a) What is matter? State the difference between homo and heterogeneous mixture. [2]

b) What are the 4 points of Dalton's Atomic Theory? [2]

c) Carry out the following mathematical operations, and give each result with the correct number of significant figures.

i. $1.05 \times 10^{-3} \div 6.135$ [2]

ii. $21 - 13.8$ [2]

iii. As part of a lab assignment to determine the value of the gas constant (R), a student measured the pressure (P), volume (V), and temperature (T) for a sample of gas, where

$$R = \frac{PV}{T}$$

The following values were obtained: $P = 2.560$, $T = 275.15$ and $V = 8.8$. Calculate R to the correct number of significant figures. [2]

d) Use the details of modern atomic theory to explain each of the following experimental observations.

i. Within a family such as the alkali metals, the ionic radius increases as the atomic number increases. [2]

ii. The radius of the chlorine atom is smaller than the radius of the chloride ion, Cl^-. (Radii : Cl atom = 0.99Å; Cl^- ion = 1.81Å) [2]

iii. The first ionization energy of aluminium is lower than the first ionization energy of magnesium. (First ionization energies: 12Mg = 7.6 ev; 13Al = 6.0 ev) [2]

iv. For magnesium, the difference between the second and third ionization energies is much larger than the difference between the first and second ionization energies. (Ionization energies for Mg: 1st = 7.6 ev; 2nd = 14 ev; 3rd = 80 ev) [2]

e) What is the difference between an emission spectrum and an absorption spectrum? Explain why the absorption spectrum of atomic hydrogen at room temperature has only the lines of the Lyman series. [2]

QUESTION 1: INTRODUCTION **[25 MARKS]**

(a) Copy Tables 1 and 2 into your answer book and complete the missing information.

(i) Fill in the names of the compounds [3]

Table 1: Compounds and their names

Number	Compound	Name of Compound
1	$CaHPO_4$	
2	S_2Cl_2	
3	N_2O_5	

(ii) Fill in the chemical formulae and the common names of the compounds. [3]

Table 2: Chemical formulae of named compounds and their common names

#	IUPAC Compound Name	Formula	Common Name
1	Dihydrogen dioxide		
2	Dinitrogen monoxide		
3	Nitrogen trihydride		

(b) Most elements occur in nature as mixtures of isotopes. Calculate the average relative atomic mass of chlorine given that naturally occurring chlorine is 75.78% ^{35}Cl (atomic mass 34.969 amu) and 24.22% ^{37}Cl (atomic mass 36.966 amu). [4]

(c) Copy Table 3 into your answer book and complete the missing isotopic information for which you will get 1 mark for each correctly completed cell. [6]

Table 3: Information on chlorine and iron isotopes

Isotope	Nucleon number	Neutron number	Electron number
^{35}Cl			
^{55}Fe			

(d) What are the commonly used alternative terms for nucleon number and electron number for an element? [2]

(e) The Table 4 below relates to separation of substances. Copy the table into your answer book and complete the missing items for ½ a mark for each correctly filled cell. [3]

Table 4: Separation of matter .

S/No	Separation method	Description of method
1		Select components by particle size
2		Select components by density
3	Crystallisation	
4	Extraction	
5		Select components by boiling point
6		Select components by affinity for a 'stationary phase'

(f) Carry out the following mathematical operations, and give each result with the correct number of significant figures.

(i) $1.05 \times 10^{-3} \div 6.135$ [1]

(ii) $21 - 13.8$ [1]

(iii) As part of a lab assignment to determine the value of the gas constant (R), a student measured the pressure (P), volume (V), and temperature (T) for a sample of gas, where

$$R = \frac{PV}{T}$$

The following values were obtained: P = 2.560, T = 275.15, and V = 8.8. (Since gases will be discussed in detail later on in the course, do not be concerned at this time about the units for these quantities.) Calculate R to the correct number of significant figures. [2]

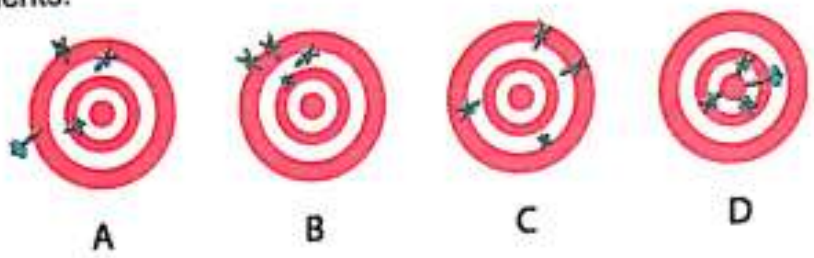
QUESTION 1: INTRODUCTION AND STOICHIOMETRY [20 MARKS]

(a) Four students weigh an item using different scales. These are the values they report:

(i) 20.03 g
(ii) 20.0 g
(iii) 0.2003 kg
(iv) 20 g

How many significant figures should be assumed in each measurement? [2]

(b) The following archery targets show marks that represent the results of four sets of measurements.



A B C D

Which target shows:

(i) a set of measurements that is both precise and accurate?
(ii) a set of measurements that is neither precise nor accurate?
(iii) a precise but inaccurate set of measurements?
(iv) an accurate but imprecise set of measurements? [2]

(c) A piece of iron (5.59 g) is ignited in a vessel containing 1.60 g of oxygen gas to form Fe_3O_4.

(i) Write a balanced equation for the reaction [1]
(ii) Deduce which reactant is in excess [2]
(iii) For the reactant in excess calculate the amount in moles by which it is in excess. [2]
(iv) Using the limiting reagent, determine how much of the product you would expect. [2]
(v) If the actual mass of the product obtained is 4.64g, calculate the percentage yield. [2]

(d) A compound contains carbon and hydrogen only. On combustion, 0.150 g of the compound gives 0.488 g CO_2 and 0.150 g H_2O. The molar mass is found to be 52.0g.

(i) What is the mass percentage of each element in the compound? [3]
(ii) Calculate the empirical formula of the compound. [2]
(iii) Calculate the molecular formula of the compound. [2]

QUESTION 1 — **25 MARKS** — **25 MARKS**

(a) If the earth's oceans contain approximately 1.36×10^{21} L of water.

i) Calculate this volume in cubic kilometres. [3]

ii) Use the appropriate prefix to write the value of 1.36×10^{9} L without exponents. [1]

(b) Copperbelt University (CBU) is situated in the town of Kitwe in Zambia whose temperature on 25 October 2017 at 14:23 hours was 30°C. What is this temperature reading in

i) Fahrenheit [1]

ii) Kelvin [1]

(c) By referring to the periodic table provided, reproduce the table below and correctly fill in the third and fourth column. *(Hint: The first row is an example of how to complete the table; 0.5 marks for each correctly filled cell)* [5]

Number	Element Symbol	Element class (metal, non-metal or metalloid)	Element group
1	He	Non-metal	Noble gas
2	Se		
3	Cu		
4	Cs		
5	Br		
6	As		

(d) What is the nuclide symbol for a nucleus that contains 38 protons and 50 neutrons? [2]

(e) Chromium, Cr, has the following isotopic masses and fractional abundances

Mass Number	Isotopic Mass (amu)	Fractional Abundance
50	49.9461	0.0435
52	51.9405	0.8379
53	52.9407	0.0950
54	53.9389	0.0236

What is the atomic mass of chromium? [2]

(f) Give the answers to the following questions

i) State the laws of definite proportions and conservation of matter. [2]

ii) Name the two types of properties commonly used to characterize or identify substances [2]

(g) Perform the following calculations and round the answers to the correct number of significant figures (units of measurement have been omitted) [4]

(i) $\frac{2.568 \times 5.8}{4.186}$ (ii) $5.41 - 0.398$ (iii) $3.38 - 0.31$ (iv) $4.18 - 58.16 \times (3.38 - 3.01)$