



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF APPLIED SCIENCES
DEPARTMENT OF APPLIED CHEMISTRY
FUNDAMENTALS OF CHEMISTRY
SCH 1117

FIRST SEMESTER EXAMINATION QUESTION PAPER
DECEMBER 2024

This examination paper consists of 12 printed pages

Time Allowed:	3 hours
Total Marks:	100
Special Requirements:	1) Physical constants & formulae (included – page 11) 2) Periodic table of the elements (included – page 12)
Internal Examiner:	Dr. M. Moyo
External Examiner:	Dr. G. Mehlana

INSTRUCTIONS & INFORMATION

1. Answer **all five** questions.
2. Where appropriate, answers should be presented in **essay or continuous writing** form. Importance should be attached to accuracy, clarity of expression and legibility of handwriting, NOT LENGTH.
3. Unless stated otherwise, all numerical answers should be expressed to **three significant figures**.

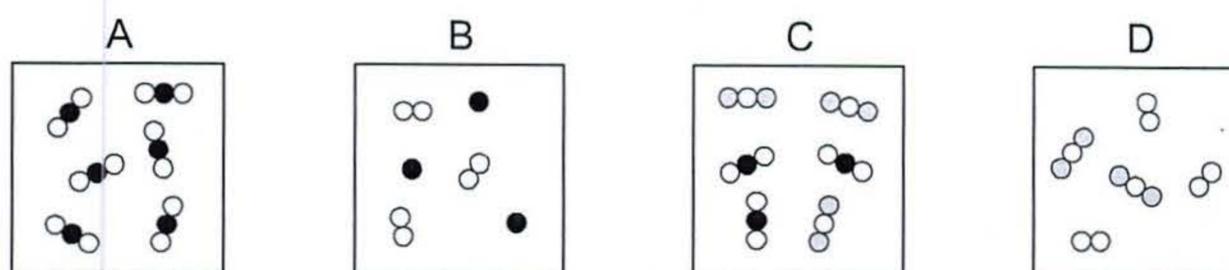
MARK ALLOCATION

QUESTION	MARKS
1.	20
2.	20
3.	20
4.	20
5.	20
TOTAL POSSIBLE MARKS	100

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- 1.3 The diagrams in **Figure 2** represent different substances. ● ○ and ○ represent atoms of three different elements.

Figure 2



- (a) Which diagram represents a mixture of compounds?
 (b) Which diagram represents a mixture of elements?
 (c) Which diagram represents a chemical?

[3 marks]

- 1.4 (a) Which of the following is a chemical change?

- A Wood is chopped for the fireplace.
 B The wax of a candle softens on a hot day.
 C Malt undergoes fermentation to make beer.
 D Water poured into a cup and placed in a freezer turns into ice.

[1 mark]

- (b) Provide an explanation for your answer to question 1.4(a).

[1 mark]

- 1.5 (a) Elements X, Y and Z have consecutive, increasing proton numbers. If Y is a noble gas, which of the following symbolizes the ions of X in its compounds?

- A X^{2-} B X^+ C X^{2+} D X^-

[1 mark]

- (b) Identify each of X, Y and Z given that two(2) of the elements are in period 5.

[3 marks]

Question 1 continues onto 1.6 on the next page

1.6 (a) Identify the odd one out among the following compounds:

A ClO_2 B MgCl_2 C NCl_3 D HCl

[1 mark]

(b) Provide a compound classification-based explanation for your answer to question 1.6(a).

[2 marks]

1.7 The fact that noble gases have low melting points is an indication that

- A they are all unreactive.
- B they have very weak forces of attraction between their particles.
- C their particles are relatively large.
- D they exist as single atoms.

[1 mark]

1.8 Provide the following:

- (a) The symbol of the heaviest alkaline earth metal.
- (b) The symbol of the halogen with the fewest electrons
- (c) The atomic number of the element in Group 5A, Period 6

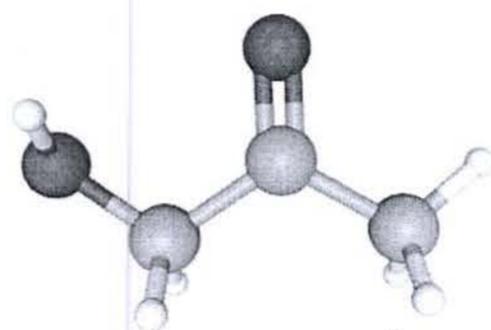
[3 marks]

End of Question 1

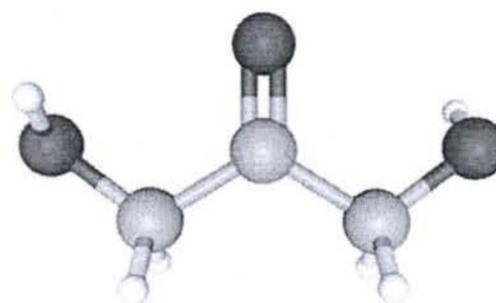
QUESTION 2

Figure 3 shows the ball and stick structure models of hydroxyacetone ($C_3H_6O_2$) and dihydroxyacetone ($C_3H_6O_3$).

Figure 3



Hydroxyacetone



Dihydroxyacetone

Hydroxyacetone, which is used as a flavouring agent or adjuvant, has a melting point of $-17\text{ }^\circ\text{C}$. Dihydroxyacetone is used in “sunless” tanning lotions, which darken the skin by reacting with the amino acids in the outer skin surface. Its melting point is $90\text{ }^\circ\text{C}$.

2.1 Using lines for bonding electron pairs, draw the Lewis structure for:

- (a) Hydroxyacetone (b) dihydroxyacetone.

[4 marks]

2.2 Copy and complete the table below, which presents selected properties of hydroxyacetone and dihydroxyacetone molecules.

Property name/description	Property value	
	Hydroxyacetone	Dihydroxyacetone
Molecular mass (g/mol)		
Formal charge		
Hydrogen bond donor count		
Hydrogen bond acceptor count		

[8 marks]

Question 2 continues onto 2.3 on the next page

2.3 (a) Do the molecules of hydroxyacetone have more kinetic energy than those of dihydroxyacetone when each compound melts? Use the compounds' melting points in conjunction with a specific concept of the kinetic theory of matter to explain.

[2 marks]

(b) When either of hydroxyacetone and dihydroxyacetone melt, what type of energy is gained by the vibrating molecules and what is the energy used for?

[2 marks]

(c) The fact that dihydroxyacetone has a much higher melting point indicates that molecules of dihydroxyacetone are held more strongly within the solid phase. Use your answers from 2.2 to give a detailed explanation of why molecules of dihydroxyacetone are held more strongly.

[4 marks]

End of Question 2

QUESTION 3

3.1 Including the necessary reaction conditions and physical state of each material, write balanced equations of the following reactions:

(a) The thermal decomposition of solid sodium azide (NaN_3) into solid sodium nitride and nitrogen gas.

(b) The gas phase reaction of ammonia (NH_3) with oxygen to form nitrogen monoxide and water over a hot ($900\text{ }^\circ\text{C}$) platinum–rhodium (Pd/Rh) catalyst.

[8 marks]

Question 3 continues onto 3.2 on the next page

3.2 Consider the following reaction that can be used to synthesize sulphur:



- (a) 0.3 L of 0.100 M H_2S and 450 of 0.050 M HNO_3 are available for the synthetic process.
- (i) How many moles of H_2S are available?
[2 marks]
- (ii) How many moles of HNO_3 are required to react with the H_2S ?
[2 marks]
- (iii) What volume of HNO_3 will completely react with the H_2S ?
[2 marks]
- (b) What mass of sulphur would be produced together with 216 g of water?
[6 marks]

End of Question 3

QUESTION 4

4.1 One way to obtain metallic iron from is mineral, iron(III) oxide, is to treat the mineral with hydrogen gas at 800 °C. Besides iron, water also forms.

- (a) Write the balanced chemical equation for the reaction. Include the necessary reaction conditions and physical state of each material.
[4 marks]
- (b) Identify the type of reaction based on comparison of the numbers of reactants and products.
[1 mark]

Question 4 continues onto 4.2 on the next page

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4.2 For a research project, a student decided to test the effect of the lead(II) ion on the ability of tilapia eggs to hatch. The ion was obtainable from the water-soluble salt, lead(II) nitrate, which the student decided to make by the reaction below.



Assuming that sufficient nitric acid would be added to react with all the lead(II) oxide, the desired product was to be isolated by slow evaporation of the water in the product mixture. Losses of the product for some reasons, which include sticking to the glassware, were expected. A yield of 90% was expected. The required quantity of lead(II) nitrate for the project (the actual yield), was 2.979 g.

(a) What specific category of matter should the product mixture be placed? Explain your choice.

[2 marks]

(b) The ratio of the actual to the theoretical yield, expressed as a percentage, is the percentage yield.

(i) Give the equation that expresses percentage yield in terms of the actual yield and theoretical yield.

[1 mark]

(ii) Calculate the theoretical yield, in g, that corresponds to the required mass (i.e. actual yield) of lead(II) nitrate.

[2 marks]

(iii) How does the number of moles in the theoretical yield compare to the number of moles of lead(II) oxide required for the reaction?

[1 mark]

(iv) How many lead ions are present in the required mass of lead(II)oxide?

[4 marks]

Question 4 continues onto 4.3 on the next page

4.3 The fractional relative atomic masses of lithium and sulphur are 6.941 amu and 32.065 amu, respectively. The four most common sulphur isotopes are sulphur-32, sulphur-33, sulphur-34, and sulphur-36.

(a) Which of the four common isotopes of sulphur is most abundant? Use the fractional relative atomic mass of sulphur to explain.

[2 marks]

(b) Lithium has two stable isotopes with consecutive isotopic masses. Identify the stable lithium isotopes?

[2 marks]

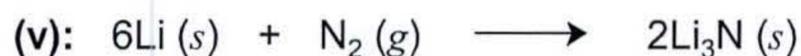
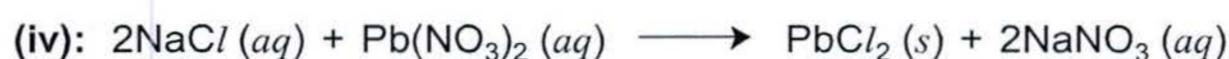
(c) Why do isotopes have similar chemical properties?

[1 mark]

End of Question 4

QUESTION 5

5.1 Consider the following reactions:



Copy and complete the table on the next page to categorize the above reactions as representations of **redox** or **precipitation** reactions. For those that are redox reactions, indicate which element is reduced and which is oxidized.

Question 5.1 continues on the next page

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Reaction label	Reaction type	If redox	
		Element reduced	Element oxidized
(i)			
(ii)			
(iii)			
(iv)			
(v)			
(vi)			

[9 marks]

- 5.2 (a) Are covalent oxides more likely to be formed by combination of oxygen with metals or non-metals? Explain your answer using periodic trends in electronegativity.

[4 marks]

- (b) Name the following oxides:

- (i) ClO_2
- (ii) Cs_2O
- (iii) P_4O_{10}
- (iv) N_2O_5
- (v) CoO_2
- (vi) SrO
- (vii) B_2O_3

[7 marks]

End of Question 5

LIST OF PHYSICAL CONSTANTS & FORMULAE

PHYSICAL CONSTANTS

Name	Symbol	Value
Standard temperature	T^θ	273 K
Standard pressure	p^θ	1.013×10^5 Pa
Molar gas volume at STP	V_m	$22.4 \text{ dm}^3 \text{ mol}^{-1}$
Avogadro's constant	N_A	$6.02 \times 10^{23} \text{ mol}^{-1}$

FORMULAE

$$n = \frac{m}{M}$$

$$n = \frac{N}{N_A}$$

$$n = \frac{V}{V_A}$$

$$c = \frac{n}{V}$$

$$c = \frac{m}{MV}$$

$$\text{pH} = -\log[\text{H}^+]$$

PERIODIC TABLE OF THE ELEMENTS

<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 5px; text-align: left;"> 1 H Hydrogen 1 </div> <div style="border: 1px solid black; padding: 5px; text-align: left;"> 2 He Helium 4 </div> </div>																																																															
3 Li Lithium 7	4 Be Beryllium 9											5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20																																														
11 Na Sodium 23	12 Mg Magnesium 24											13 Al Aluminium 27	14 Si Silicon 28	15 P Phosphorous 31	16 S Sulphur 32	17 Cl Chlorine 35.5	18 Ar Argon 40																																														
19 K Potassium 40	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 64	30 Zn Zinc 65	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84																																														
37 Rb Rubidium 85	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Mo Molybdenum 96	43 Tc Technetium	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131																																														
55 Cs Caesium 133	56 Ba Barium 137	57-71 La	72 Hf Hafnium 178	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium	85 At Astatine	86 Rn Radon																																														
87 Fr Francium	88 Ra Radium	89-103 Ac	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson																																														
Lanthanoid series		<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td>57 La Lanthanum 139</td> <td>58 Ce Cerium 140</td> <td>59 Pr Praseodymium 141</td> <td>60 Nd Neodymium 144</td> <td>61 Pm Promethium</td> <td>62 Sm Samarium 150</td> <td>63 Eu Europium 152</td> <td>64 Gd Gadolinium 157</td> <td>65 Tb Terbium 159</td> <td>66 Dy Dysprosium 162</td> <td>67 Ho Holmium 165</td> <td>68 Er Erbium 167</td> <td>69 Tm Thulium 169</td> <td>70 Yb Ytterbium 173</td> <td>71 Lu Lutetium 175</td> </tr> <tr> <td colspan="2">Actinoid series</td> <td colspan="14"> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td>89 Ac Actinium 227</td> <td>90 Th Thorium 232</td> <td>91 Pa Protactinium</td> <td>92 U Uranium 238</td> <td>93 Np Neptunium</td> <td>94 Pu Plutonium</td> <td>95 Am Americium</td> <td>96 Cm Curium</td> <td>97 Bk Berkelium</td> <td>98 Cf Californium</td> <td>99 Es Einsteinium</td> <td>100 Fm Fermium</td> <td>101 Md Mendelevium</td> <td>102 No Nobelium</td> <td>103 Lr Lawrencium</td> </tr> </table> </td> </tr> </table>																57 La Lanthanum 139	58 Ce Cerium 140	59 Pr Praseodymium 141	60 Nd Neodymium 144	61 Pm Promethium	62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 162	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175	Actinoid series		<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td>89 Ac Actinium 227</td> <td>90 Th Thorium 232</td> <td>91 Pa Protactinium</td> <td>92 U Uranium 238</td> <td>93 Np Neptunium</td> <td>94 Pu Plutonium</td> <td>95 Am Americium</td> <td>96 Cm Curium</td> <td>97 Bk Berkelium</td> <td>98 Cf Californium</td> <td>99 Es Einsteinium</td> <td>100 Fm Fermium</td> <td>101 Md Mendelevium</td> <td>102 No Nobelium</td> <td>103 Lr Lawrencium</td> </tr> </table>														89 Ac Actinium 227	90 Th Thorium 232	91 Pa Protactinium	92 U Uranium 238	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium
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End of question paper

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