



SIR ARTHUR LEWIS COMMUNITY COLLEGE
ACADEMIC YEAR (2024/2025) – SEMESTER ONE
END OF SEMESTER EXAMINATION

COURSE CODE : CHM107
COURSE TITLE : Physical Chemistry
LECTURER(S) : Alberta William-Henry, Jolie Pistol
DATE : 9th December 2024
TIME : 9 a.m. to 11 a.m.
DURATION : 2 Hours
STUDENT ID # : _____



GENERAL INFORMATION AND INSTRUCTIONS

- Students must sign **IN** and **OUT** on the examination class list.
- Write your ID number on the question paper.
- Answer ALL questions in Section A and ALL questions in Section B.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

SECTION A – Multiple choice

Shade the correct response

1. Which of the following statements is NOT a part of Dalton's atomic theory?
 - (a) Atoms are indivisible
 - (b) Atoms are characterized by their atomic number
 - (c) The atoms of an element have identical properties
 - (d) The atoms of an element differ from those of other elements
2. How many moles are in 25.25g of Mg?
 - (a) 2.10g
 - (b) 1.03g
 - (c) 1.04g
 - (d) 0.962g
3. Which of the following ions has the **greatest** polarizing power?
 - (a) Be^{2+}
 - (b) Ca^{2+}
 - (c) Li^{+}
 - (d) Sr^{2+}
4. The simplest formula for a compound that contains 50% S and 50% O by mass is
 - (a) SO
 - (b) SO_2
 - (c) S_2O
 - (d) S_2O_4
5. The second ionization energy of calcium is 1150 kJ/mol. Which of the following equations represents this statement?

	kJ/mol
(a) $\text{Ca}_{(\text{g})} \rightarrow \text{Ca}^{2+}_{(\text{g})} + 2\text{e}$	-1150
(b) $\text{Ca}^{+}_{(\text{g})} \rightarrow \text{Ca}^{2+}_{(\text{g})} + \text{e}$	-1150
(c) $\text{Ca}_{(\text{g})} \rightarrow \text{Ca}^{2+}_{(\text{g})} + 2\text{e}$	+1150
(d) $\text{Ca}^{+}_{(\text{g})} \rightarrow \text{Ca}^{2+}_{(\text{g})} + \text{e}$	+1150
6. This question refers to the following standard enthalpies of combustion for carbon, hydrogen and octane.

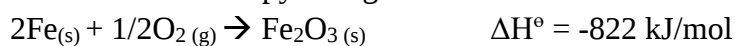
$\Delta H_{\text{c}}^{\circ}$	kJ/mol
Carbon	-394
Hydrogen	-286
Octane	-5476

The standard enthalpy of formation of octane, $\Delta H^{\circ}_{\text{f}}$ is calculated using

- (a) $\Delta H^{\circ}_{\text{f}} (\text{octane}) = -8(-394) - 9(-286) - 5476$
- (b) $\Delta H^{\circ}_{\text{f}} (\text{octane}) = -8(-394) - 9(-286) - (-5476)$
- (c) $\Delta H^{\circ}_{\text{f}} (\text{octane}) = 8(-394) + 9(-286) - (-5476)$
- (d) $\Delta H^{\circ}_{\text{f}} (\text{octane}) = 8(-394) - 9(-286) - (-5476)$

7. What shape describes the molecule water?
 - (a) Linear
 - (b) Trigonal planar
 - (c) Tetrahedral
 - (d) Non-linear
8. Which of the following factors increases the first ionization energy of an atom?
 - (a) Increased screening by inner electrons
 - (b) Larger number of valence electrons
 - (c) Greater nuclear charge
 - (d) Larger atomic radius
9. How many hydrogen bonds can be formed with the oxygen atom in a molecule of water?
 - (a) 1
 - (b) 2
 - (c) 3
 - (d) 4

10. The standard enthalpy changes for two reactions are as follows:



What is the standard enthalpy change for the reaction



- (a) -932
 - (b) -712
 - (c) -492
 - (d) +492
11. What is the average relative atomic mass of bromine given the following isotopic masses and relative abundance?

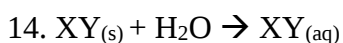
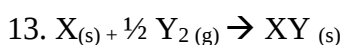
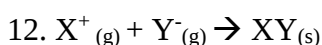
^{79}Br 50.5%	^{81}Br 49.5%
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 - (a) 80.01
 - (b) 79.99
 - (c) 79.90
 - (d) 78.99

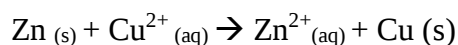
Items 12-14 refers to the following options

- (a) Enthalpy of formation
- (b) Lattice energy
- (c) Enthalpy of solution
- (d) Enthalpy of hydration

Match EACH item below with one of the options above, each of which may be used once, more than once or not at all.



15. What is the standard heat of reaction ΔH_r at 101.325 kPa or pressure and 298K, for the equation given below?



$\Delta H^\circ_f = +64.4 \text{ kJ/mol}$ for Cu^{2+}

$\Delta H^\circ_f = -152.4 \text{ kJ/mol}$ for Zn^{2+}

$\Delta H^\circ_f = 0 \text{ kJ/mol}$ for both Zn and Cu

- (a) +217 kJ/mole
 - (b) +88.0 kJ/mole
 - (c) -88.0 kJ/mole
 - (d) -217 kJ/mole
16. Which of the following species has a structure with a bond angle less than 109° ?
- (a) NF_3
 - (b) NH_4^+
 - (c) CH_4
 - (d) BF_3
17. An ion Z^{3+} contains 23 protons. What is the electronic configuration of Z^{3+} ?
- (a) $[\text{Ar}]3d^04s^1$
 - (b) $[\text{Ar}]3d^2$
 - (c) $[\text{Ar}]3d^34s^2$
 - (d) $[\text{Ar}]3d^64s^2$
18. A π bond results from the overlapping of
- (a) Two s orbitals
 - (b) One s and one p orbital
 - (c) Two p orbitals end on
 - (d) Two p orbitals sideways
19. The bonds in SO_4^{2-} are best described as
- (a) Covalent and polar
 - (b) Ionic and polar
 - (c) Polar, covalent and single
 - (d) Polar, covalent and double
20. The bond angles in the PH_3 molecule are the same as that of NCl_3 . Its shape would BEST be described as
- (a) Bipyramidal
 - (b) Pyramidal
 - (c) Tetrahedral
 - (d) Trigonal
21. Which of the following solids has a giant molecular lattice?
- (a) Copper
 - (b) Carbon dioxide
 - (c) Magnesium oxide
 - (d) Silicon dioxide

22. Which of the following characteristics of oxygen BEST explains why the first ionization energy of oxygen is lower than that of nitrogen?
- (a) A smaller atomic radius
 - (b) Greater shielding by inner electrons
 - (c) Greater effective nuclear charge
 - (d) Repulsion between the paired 2p electrons
23. Which of the following pairs of elements would be expected to form the compound with the MOST ionic character?
- (a) Li and F
 - (b) Li and I
 - (c) Rb and F
 - (d) Rb and I
24. The van der Waals forces consist of
- (a) Permanent dipole-permanent dipole interactions
 - (b) Induced dipole-induced dipole interactions
 - (c) Permanent dipole-induced dipole covalent interactions
 - (d) Dipole-dipole; dipole-induced dipole ionic interactions
25. Which of the following is NOT an endothermic process?
- (a) Ice melting
 - (b) Water boiling
 - (c) Water evaporating
 - (d) Water condensing
26. The high melting point of graphite can be attributed to
- (a) Delocalized electrons
 - (b) Hexagonal arrangement of the carbon atoms
 - (c) Strong covalent bonds within the layers
 - (d) Van der Waals' forces between the layers
27. Which of the following describes potassium bromide?
- (a) A network of covalently bonded atoms
 - (b) A substance which boils at 59 °C and decomposes at high temperature
 - (c) A solid with a very high molar enthalpy of vaporization and in a liquid state, does not conduct electricity
 - (d) A non-conducting solid which melts to form a liquid that conducts electricity
28. When 86g of the ionic salt, $\text{CaSO}_4 \cdot x\text{H}_2\text{O}$, is heated so that all of its water of crystallization is driven off and 68.0 g of CaSO_4 remain, the value of x is
- (a) 1
 - (b) 2
 - (c) 3
 - (d) 4
29. For complete reaction, 0.25g of a monobasic acid requires 10cm^3 of 0.2 mol/dm^3 sodium hydroxide. What is the relative molecular mass of the acid in g/mol?
- (a) 12.5
 - (b) 62.5
 - (c) 125
 - (d) 250

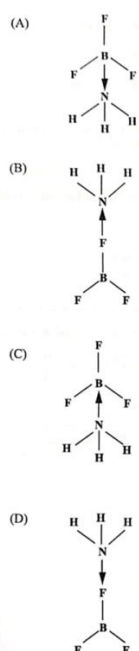
30. The equation which represents the enthalpy of atomization of bromine is

- (a) $\frac{1}{2} \text{Br}_2 (\text{l}) \rightarrow \text{Br} (\text{g})$
- (b) $\frac{1}{2} \text{Br}_2 (\text{g}) \rightarrow \text{Br} (\text{g})$
- (c) $\text{Br}_2 (\text{g}) \rightarrow 2 \text{Br} (\text{g})$
- (d) $\text{Br}_2 (\text{l}) \rightarrow 2 \text{Br} (\text{g})$

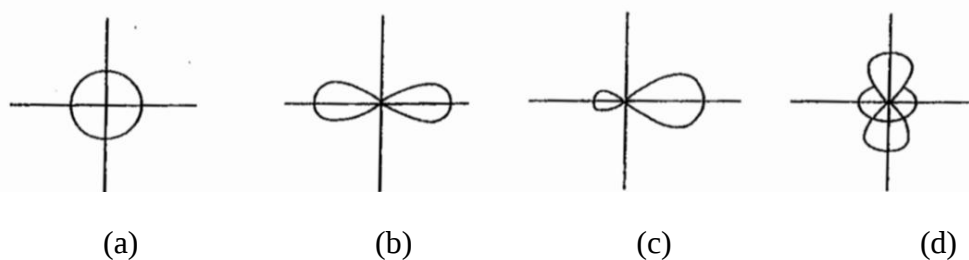
31. Which of the following has a simple molecular structure?

- (a) Na_2O
- (b) SiO_2
- (c) Al_2O_3
- (d) SO_3

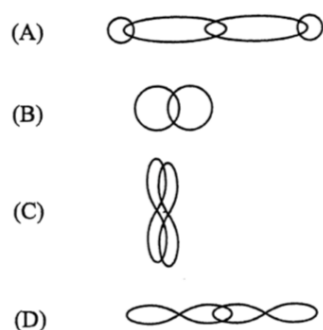
32. Which of the following structures correctly illustrates the coordinate bonding between BF_3 and NH_3 ?



33. Which of the diagrams below BEST represents an sp^3 orbital?



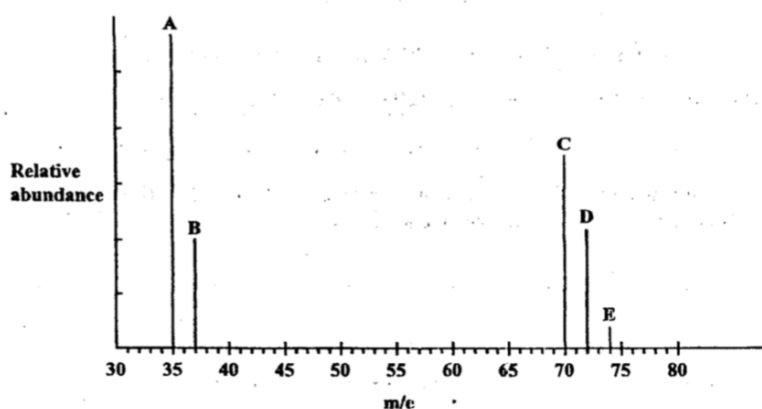
34. Which of the following diagrams represents a pi bond?



35. The intermolecular forces which are present in ice are

- (a) Ionic bonds
- (b) Covalent bonds
- (c) Hydrogen bonds
- (d) Van der Waals forces

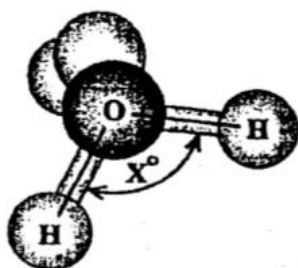
Item 36 refers to the following mass spectrum of chlorine gas



36. If the peak at A represents the $^{35}\text{Cl}^+$ ion, which of the following ions represent the peaks at B and E

- (a) $^{37}\text{Cl}^+$ and $(^{37}\text{Cl}-^{37}\text{Cl})^+$
- (b) $^{37}\text{Cl}^+$ and $(^{37}\text{Cl}-^{35}\text{Cl})^+$
- (c) $^{37}\text{Cl}^+$ and $(^{35}\text{Cl}-^{35}\text{Cl})^+$
- (d) $^{37}\text{Cl}^+$ and $(^{35}\text{Cl}-^{37}\text{Cl})^+$

37. What is the value of X in the following diagram?

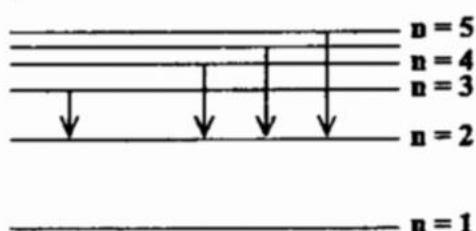


- (a) 104.5
- (b) 109.5
- (c) 120
- (d) 180

38. Which of the following is the configuration of Cu (I) ion?

- (a) $[\text{Ar}] 3d^{10}$
- (b) $[\text{Ar}] 3d^8 4s^2$
- (c) $[\text{Ar}] 3d^9 4s^1$
- (d) $[\text{Ar}] 3d^{10} 4s^1$

Item 39 refers to the following diagram which shows the energy levels for the hydrogen atom and the electronic transitions which produce lines in the visible region



39. Which of the series below involves transitions from higher energy levels to $n=2$ level?
- (a) Balmer
 - (b) Dalton
 - (c) Lyman
 - (d) Paschen

Item 40 refers to the data in the following table

Atomic Mass (amu)	Abundance (%)
²⁰⁴ Pb	1.4
²⁰⁶ Pb	24.1
²⁰⁷ Pb	22.1
²⁰⁸ Pb	52.4

40. Based on the data in the table above, the relative isotopic mass of lead is
- (a) 206.24 amu
 - (b) 207.24 amu
 - (c) 207.30 amu
 - (d) 208.30 amu

Section B

Question 1

(i) Draw, name and explain the difference between the shapes of NH_3 and NH_4^+ commenting on the angle & repulsion which exist.

[5 marks]

(ii) Ammonia gas is able to be liquified by decreasing temperature and increasing pressure. Explain the bonding in ammonia gas and why it is possible to be liquified.

[3 marks]

(iii) Write electronic configurations for the following:

N^{3-}

Cu^+

[2 marks]

Question 2

Bond energies can be used to estimate the enthalpies of reactions in which bonds are broken and new bonds are formed. Consider the **gas-phase** reaction between methane (CH₄) and chlorine to produce methyl chloride (CH₃Cl) and hydrogen chloride.

(i) Write a balanced equation to represent the reaction above.

[2 marks]

(ii) Using bond energy values from table 1, calculate the enthalpy change of reaction, ΔH_{rxn} , for the equation required in (b) (i).

[5 marks]

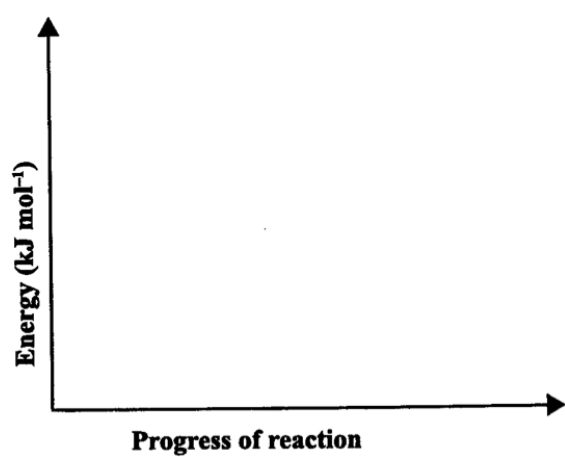
TABLE 1: BOND ENERGY VALUES

Bond	Energy (kJ mol ⁻¹)
H—H	436
F—F	158
Cl—Cl	244
H—F	562
H—Cl	431
C—C	350
C—H	410
C—Cl	340
C—O	360
S—H	347

(ii) Is the reaction in (b) (i) exothermic or endothermic?

[1 mark]

(iii) On the axes provided below, draw the energy-profile diagram for the reaction.



[2 marks]