



UNIVERSITY
OF
JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF CHEMICAL SCIENCES

B Eng Tech in Engineering Metallurgy / Extraction Metallurgy

MODULE CETM1A1

CAMPUS DFC

MAJOR TEST 2

DATE: 24/05/2021

SESSION: 08H00 – 10:00

ASSESSOR

Dr. MC FOTSING

INTERNAL MODERATOR

MR P.P MONAMA

DURATION 120 MINUTES

TOTAL MARKS 70

NUMBER OF PAGES: 4 PAGES, INCLUDING 1 ANNEXURE

INSTRUCTIONS: ANSWER ALL QUESTIONS IN THE ANSWER SCRIPT PROVIDED.

GIVE ALL NUMERICAL ANSWERS TO THE CORRECT NUMBER OF SIGNIFICANT FIGURES AND WITH APPROPRIATE UNITS.

CONSULT THE DATA SHEET AND THE PERIODIC TABLE FOR ALL SUPPLEMENTARY INFORMATION.

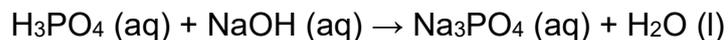
CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT).

REQUIREMENTS: ANSWER SCRIPT

QUESTION 1

Choose the right answer.

1. When the following equation is balanced, the coefficient of H_3PO_4 is _____.



- A) 1
- B) 2
- C) 3
- D) 4
- E) 0

Answer: A

Diff: 1 Page Ref: Sec. 3.1

2. There are _____ molecules of methane in 0.123 mol of methane (CH_4).

- A) 5
- B) 2.46×10^{-2}
- C) 2.04×10^{-25}
- D) 7.40×10^{22}
- E) 0.615

Answer: D

Diff: 2 Page Ref: Sec. 3.4

3. How many grams of oxygen are in 65 g of $\text{C}_2\text{H}_2\text{O}_2$?

- A) 18
- B) 29
- C) 9.0
- D) 36
- E) 130

Answer: D

Diff: 3 Page Ref: Sec. 3.4

4. What is the empirical formula of a compound that contains 49.4% K, 20.3% S, and 30.3% O by mass?

- A) KSO_2
- B) KSO_3
- C) K_2SO_4
- D) K_2SO_3
- E) KSO_4

Answer: D

Diff: 3 Page Ref: Sec. 3.5

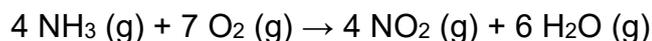
5. A compound is composed of only C, H, and O. The combustion of a 0.519-g sample of the compound yields 1.24 g of CO₂ and 0.255 g of H₂O. What is the empirical formula of the compound?

- A) C₆H₆O
- B) C₃H₃O
- C) CH₃O
- D) C₂H₆O₅
- E) C₂H₆O₂

Answer: B

Diff: 4 Page Ref: Sec. 3.

6. The combustion of ammonia in the presence of excess oxygen yields NO₂ and H₂O:



The combustion of 28.8 g of ammonia consumes _____ g of oxygen.

- A) 94.9
- B) 54.1
- C) 108
- D) 15.3
- E) 28.8

Answer: A

Diff: 3 Page Ref: Sec. 3.6

7. The molecular weight of the acetic acid (CH₃CO₂H) is _____ amu.

- A) 60
- B) 48
- C) 44
- D) 32
- E) 22

Answer: A

Diff: 1 Page Ref: Sec. 3.3

8. The mass % of F in the binary compound KrF₂ is _____.

- A) 18.48
- B) 45.38
- C) 68.80
- D) 81.52
- E) 31.20

Answer: E

Diff: 2 Page Ref: Sec. 2.4

9. In the Lewis symbol for a fluorine atom, there are _____ paired and _____ unpaired electrons.

- A) 4, 2
- B) 4, 1
- C) 2, 5
- D) 6, 1
- E) 0, 5

Answer: D

Diff: 1 Page Ref: Sec. 8.1

10. Based on the octet rule, phosphorus most likely forms a _____ ion.

- A) P^{3+}
- B) P^{3-}
- C) P^{5+}
- D) P^{5-}
- E) P^+

Answer: B

Diff: 1 Page Ref: Sec. 8.1

11. The electron configuration of the S^{2-} ion is _____.

- A) $[Ar]3s^23p^6$
- B) $[Ar]3s^23p^2$
- C) $[Ne]3s^23p^2$
- D) $[Ne]3s^23p^6$
- E) $[Kr]3s^2 2p^6$

Answer: D

Diff: 1 Page Ref: Sec. 8.2

12. The ability of an atom in a molecule to attract electrons is best quantified by the _____.

- A) paramagnetism
- B) diamagnetism
- C) electronegativity
- D) electron change-to-mass ratio
- E) first ionization potential

Answer: C

Diff: 1 Page Ref: Sec. 8.4

13. Given the electronegativities below, which covalent single bond is most polar?

Element: H C N O

Electronegativity: 2.1 2.5 3.0 3.5

- A) C–H
- B) N–H
- C) O–H
- D) O–C
- E) O–N

Answer: C

Diff: 1 Page Ref: Sec. 8.4

14. The ion NO^- has _____ valence electrons.

- A) 15
- B) 14
- C) 16
- D) 10
- E) 12

Answer: E

Diff: 1 Page Ref: Sec. 8.5

15. The Lewis structure of PF_3 shows that the central phosphorus atom has _____ nonbonding and _____ bonding electron pairs.

- A) 2, 2
- B) 1, 3
- C) 3, 1
- D) 1, 2
- E) 3, 3

Answer: B

Diff: 1 Page Ref: Sec. 8.5

16. According to VSEPR theory, if there are four electron domains in the valence shell of an atom, they will be arranged in a(n) _____ geometry.

- A) octahedral
- B) linear
- C) tetrahedral
- D) trigonal planar
- E) trigonal bipyramidal

Answer: C

Diff: 1 Page Ref: Sec. 9.2

17. Which of the following compounds would you expect to be ionic?

- A) H₂O
- B) CO₂
- C) SrCl₂
- D) SO₂
- E) H₂S

Answer: C

Diff: 1 Page Ref: Sec. 2.7

18. Which species below is the nitrate ion?

- A) NO₂⁻
- B) NH₄⁺
- C) NO₃⁻
- D) N₃⁻
- E) N³⁻

Answer: C

Diff: 1 Page Ref: Sec. 2.7

19. Which one of the following compounds is copper(I) chloride?

- A) CuCl
- B) CuCl₂
- C) Cu₂Cl
- D) Cu₂Cl₃
- E) Cu₃Cl₂

Answer: A

20. The hybridization of the carbon atom in carbon dioxide is _____.

- A) sp
- B) sp²
- C) sp³
- D) sp³d
- E) sp³d²

Answer: A

Diff: 1 Page Ref: Sec. 9.5

21. In order to produce sp³ hybrid orbitals, _____ s atomic orbital(s) and _____ p atomic orbital(s) must be mixed.

- A) one, two
- B) one, three
- C) one, one
- D) two, two
- E) two, three

Answer: B

Diff: 1 Page Ref: Sec. 9.5

22. There are _____ σ and _____ π bonds in the $\text{H}_2\text{C}=\text{C}=\text{CH}_2$ molecule.

- A) 4, 2
 B) 6, 4
 C) 2, 2
 D) 2, 6
 E) 6, 2

Answer: E

Diff: 1 Page Ref: Sec. 9.6

[44]

QUESTION 2

2.1 Calculate the percentage by mass of oxygen in the following compounds:

2.1.1 Morphine, $\text{C}_{17}\text{H}_{19}\text{NO}_3$ (2)

2.1.2 Cocaine, $\text{C}_{17}\text{H}_{21}\text{NO}_4$ (2)

2.2 The empirical formula of the following compounds is given. What is the molecular formula of each of the following compounds?

2.2.1 Empirical formula CH_2 , molar mass = 84 g/mol (2)

2.2.2 Empirical formula NH_2Cl , molar mass = 51.5 g/mol (2)

2.1.1

3.23 *Plan.* Calculate the formula weight (FW), then the mass % oxygen in the compound.
Solve.

(a) $\text{C}_{17}\text{H}_{19}\text{NO}_3$: $\text{FW} = 17(12.0) + 19(1.0) + 1(14.0) + 3(16.0) = 285.0 \text{ amu}$
 $\% \text{ O} = \frac{3(16.0) \text{ amu}}{285.0 \text{ amu}} \times 100 = 16.842 = 16.8\%$

2.1.2

(b) $\text{C}_{18}\text{H}_{21}\text{NO}_3$: $\text{FW} = 18(12.0) + 21(1.0) + 1(14.0) + 3(16.0) = 299.0 \text{ amu}$

(c) $\text{C}_{17}\text{H}_{21}\text{NO}_4$: $\text{FW} = 17(12.0) + 21(1.0) + 1(14.0) + 4(16.0) = 303.0 \text{ amu}$
 $\% \text{ O} = \frac{4(16.0) \text{ amu}}{303.0 \text{ amu}} \times 100 = 21.122 = 21.1\%$

$\% \text{ O} = \frac{4(16.0) \text{ amu}}{303.0 \text{ amu}} \times 100 = 21.122 = 21.1\%$

(d) $\text{C}_{22}\text{H}_{24}\text{N}_2\text{O}_8$: $\text{FW} = 22(12.0) + 24(1.0) + 2(14.0) + 8(16.0) = 444.0 \text{ amu}$

$\% \text{ O} = \frac{8(16.0) \text{ amu}}{444.0 \text{ amu}} \times 100 = 28.829 = 28.8\%$

(e) $\text{C}_{41}\text{H}_{64}\text{O}_{13}$: $\text{FW} = 4(12.0) + 64(1.0) + 13(16.0) = 764.0 \text{ amu}$

$\% \text{ O} = \frac{13(16.0) \text{ amu}}{764 \text{ amu}} \times 100 = 27.225 = 27.2\%$

(f) $\text{C}_{66}\text{H}_{75}\text{Cl}_2\text{N}_9\text{O}_{24}$: $\text{FW} = 66(12.0) + 75(1.0) + 2(35.5) + 9(14.0) + 24(16.0) = 1448.0 \text{ amu}$

$\% \text{ O} = \frac{24(16.0) \text{ amu}}{1448.0 \text{ amu}} \times 100 = 26.519 = 26.5\%$

2.2.1

3.49 *Analyze.* Given: empirical formula, molar mass. Find: molecular formula.

Plan. Calculate the empirical formula weight (FW); divide FW by molar mass (MM) to calculate the integer that relates the empirical and molecular formulas. Check. If FW/MM is an integer, the result is reasonable. *Solve.*

$$(a) \quad \text{FW CH}_2 = 12 + 2(1) = 14. \quad \frac{\text{MM}}{\text{FW}} = \frac{84}{14} = 6$$

The subscripts in the empirical formula are multiplied by 6. The molecular formula is C₆H₁₂.

2.2.2

$$(b) \quad \text{FW NH}_2\text{Cl} = 14.01 + 2(1.008) + 35.45 = 51.48. \quad \frac{\text{MM}}{\text{FW}} = \frac{51.5}{51.5} = 1$$

The empirical and molecular formulas are NH₂Cl.

QUESTION 3

When benzene (C₆H₆) reacts with bromine (Br₂), bromobenzene (C₆H₅Br) is obtained:



- 3.1 When 30.0 g of benzene reacts with 65.0 g of bromine, what is the theoretical yield of bromobenzene? (6)
- 3.2 If the actual yield of bromobenzene is 42.3 g, what is the percentage yield? (4)

3.1

3.81 *Analyze.* Given: amounts of two reactants. Find: theoretical yield.

Plan. Determine the limiting reactant and the maximum amount of product it could produce. Then calculate % yield. *Solve.*

$$(a) \quad 30.0 \text{ g C}_6\text{H}_6 \times \frac{1 \text{ mol C}_6\text{H}_6}{78.11 \text{ g C}_6\text{H}_6} = 0.3841 = 0.384 \text{ mol C}_6\text{H}_6$$

$$65.0 \text{ g Br}_2 \times \frac{1 \text{ mol Br}_2}{159.8 \text{ g Br}_2} = 0.4068 = 0.407 \text{ mol Br}_2$$

Since C_6H_6 and Br_2 react in a 1:1 mole ratio, C_6H_6 is the limiting reactant and determines the theoretical yield.

$$0.3841 \text{ mol C}_6\text{H}_6 \times \frac{1 \text{ mol C}_6\text{H}_5\text{Br}}{1 \text{ mol C}_6\text{H}_6} \times \frac{157.0 \text{ g C}_6\text{H}_5\text{Br}}{1 \text{ mol C}_6\text{H}_5\text{Br}} = 60.30 = 60.3 \text{ g C}_6\text{H}_5\text{Br}$$

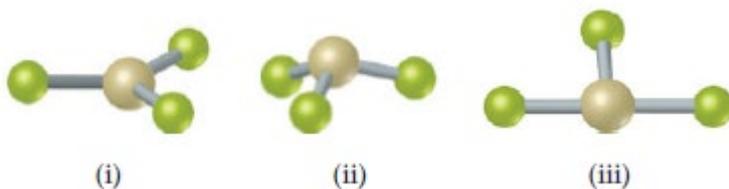
Check. $30/78 \sim 3/8 \text{ mol C}_6\text{H}_6$. $65/160 \sim 3/8 \text{ mol Br}_2$. Since moles of the two reactants are similar, a precise calculation is needed to determine the limiting reactant. $3/8 \times 160 \approx 60 \text{ g product}$

----- 42.3 g $\text{C}_6\text{H}_5\text{Br}$ actual -----

$$(b) \quad \% \text{ yield} = \frac{42.3 \text{ g C}_6\text{H}_5\text{Br actual}}{60.3 \text{ g C}_6\text{H}_5\text{Br theoretical}} \times 100 = 70.149 = 70.10\%$$

QUESTION 4

The figure that follows shows ball-and-stick drawings of three possible shapes of an AF_3 molecule.



4.1 For each shape, give the electron-domain geometry on which the molecular geometry is based (3)

4.2 For each shape, how many nonbonding electron domains are there on atom A? (2)

4.1

Electron domain geometries

i) trigonal planar

ii) tetrahedral

iii) trigonal bipyramidal

a)*Analyze/Plan.* Work backwards from molecular geometry, using Tables 9.2 and 9.3.*Solve.*

- (a) Electron-domain geometries: i, trigonal planar; ii, tetrahedral; iii, trigonal bipyramidal

4.2**Non bonding electron domains:**

- i) 0
ii) 1
iii) 2

- (b) nonbonding electron domains: i, 0; ii, 1; iii, 2

[10]**QUESTION 4**

Which of the following compounds are ionic and which are molecular?

- a) PF_5
b) NaI
c) SCl_2
d) $\text{Ca}(\text{NO}_3)_2$
e) FeCl_3
f) LaP
g) CoCO_3
h) N_2O_4

(8)**2.60** Molecular (all elements are nonmetals):

- (a) PF_5 (c) SCl_2 (h) N_2O_4

Ionic (formed from ions, usually contains a metal cation):

- (b) NaI (d) $\text{Ca}(\text{NO}_3)_2$ (e) FeCl_3 (f) LaP (g) CoCO_3

Molecular (All elements are non metals)

- a) PF_5 c) SCl_2 h) N_2O_4

Ionic (Formed from ions, usually contains a metal cations)

- b) NaI d) $\text{Ca}(\text{NO}_3)_2$ e) FeCl_3 f) LaP g) CoCO_3

[8]

QUESTION 3

[15]

QUESTION 4

[9]

TOTAL MARKS : 70

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Department of Applied Chemistry

1 H 1.0079	
3 Li 6.941	4 Be 9.0122
11 Na 22.990	12 Mg 24.305
19 K 39.098	20 Ca 40.078
37 Rb 85.47	38 Sr 87.62
55 Cs 132.91	56 Ba 137.33
87 Fr (223)	88 Ra 226.03

Atomic Number

2 He 4.0026

Atomic Weight

5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)

21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39
39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41
57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59
89 Ac 227.03									

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk 247	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)