Addis Ababa Science and Technology University

Department of Industrial Chemistry

General Chemistry (Chem 1011) Final Exam Time allotted: 2:30 hr Date: August 5, 2022

Name _____ ID. No. _____ Section: _____

General Instruction: The Exam paper contains **44** questions in **4** parts.

Attempt all questions

Mark Distribution:

	Mark allocated (50%)	Mark Scored
Part I	**30**	
Part II	**4**	
Part III	**6**	
Part IV	**10**	
	Total Score	

1																	18
1 H 1.0079	2											13	14	15	16	17	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305	3	4	5	6	7	8	9	10	11	12	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.409	31 Ga 69.723	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.798
37 Rb 85.468	38 Sr 87.62	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	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57–71 *	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89–103 #	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)			

Physical constants

Planck constant (h) = 6.63×10^{-34} Js Speed of light in vacuum (c) = 3.0×10^{8} m/s

Part I: Choose the answer from the given alternatives and write the letter of your choice inside the shaded region. (1 pts each)

1. Gaseous state of matter that contains appreciable numbers of electrically charged particles [D]
   A. Gas B. Liquid C. Solid D. Plasma
2. Convert 125 Ethiopian birr to pound sterling assuming 1 pound equals 64.53 birr. [B]
   A. 1.93 B. 1.94 C. 1.937 D. 1.940
3. _____ is a chemical formula that shows the connectivity of atom in a [C] molecule.
   A. Empirical Formula B. Molecular Formula C. Structural Formula D. All
4. Which of the following is **not** polyatomic anion? [A]
   A. O^{2-} B. CO_3^{2-} C. SO_4^{2-} D. SO_3^{2-}
5. Which of the following is binary compound? [B]
   A. Sodium Carbonate B. Magnesium Nitride
   C. Ammonium Chloride D. Calcium Sulfate
6. Which one of the following is the molecular formula of dichlorine hept(a)oxide? [C]
   A. ClO_7 B. ClO_6 C. Cl_2O_7 D. Cl_2O_6
7. What is the mass number of an atom that has 26 protons, 30 neutrons, and 24 electrons? [B]
   A. 54 B. 56 C. 26 D. 80
8. The majority of the mass of an atom is held by [B]
   A. Proton and Electron B. Electron only
   C. Electron and Neutron D. Proton and Neutron
9. Which of the following is **not** true regarding balanced chemical equations? [C]
   A. They contain the same number of atoms on each side
   B. Electrons are also balanced
   C. An equal number of molecules on both side
   D. Follows the law of conservation of mass
10. Which of the given reactions are counted as balanced reactions? [B]
    A. $H_2 + O_2 \rightarrow 2H_2O$
    B. $4Al + 3O_2 \rightarrow 2Al_2O_3$
    C. $Mg(OH)_2 + 2HNO_3 \rightarrow 2Mg(NO_3)_2 + 2H_2O$
    D. $N_2 + 3H_2 \rightarrow NH_3$
11. Calculate the mass percentage of magnesium in the formation of magnesium oxide. [D]
    A. 30% B. 48% C. 54% D. 60%

12. Balance the following equation using minimum integral coefficients: D

$NH_3 + O_2 \rightarrow NO_2 + H_2O$

The stoichiometric coefficient for oxygen gas O_2 is:

A. 1 B. 4 C. 3 D. 7

13. How many moles of alanine, $C_3H_7NO_2$, are there in 159 g of alanine? B

A. 1.42×10^4 B. 1.78 C. 0.992 D. 0.560

14. Which one of the samples has the largest mass? B

A. 1 mol of CO_2 B. 1 mol of SF_6 C. 1 mol of CH_3COCH_3 D. 1 mol of He

15. Calculate the percent, by weight, of carbon in 154 g of $C_4H_8O_3$? A

A. 46% B. 31% C. 72% D. 55%

16. How many grams of $Ca(OH)_2$ are contained in 1500 mL of 0.0250 M $Ca(OH)_2$ solution? C

A. 3.17 g B. 2.78 g C. 1.85 g D. 2.34 g

17. Which of the following statements is **FALSE** for the chemical equation given below in which nitrogen gas reacts with hydrogen gas to form ammonia gas assuming the reaction goes to completion? D

$N_2 + 3H_2 \rightarrow 2NH_3$

A. The reaction of one mole of H_2 will produce 2/3 moles of NH_3.

B. One mole of N_2 will produce two moles of NH_3.

C. The reaction of 14 g of nitrogen produces 17 g of ammonia.

D. The reaction of three moles of hydrogen gas will produce 17 g of ammonia.

18. When 12 g of methanol (CH_3OH) was treated with excess oxidizing agent (MnO_4^-), 14 g of formic acid (HCOOH) was obtained. Using the following chemical equation, calculate the percent yield. (The reaction is much more complex than this; please ignore the fact that the charges do not balance.) C

$3CH_3OH + 4MnO_4^- \rightarrow 3HCOOH + 4MnO_2$

A. 100% B. 92% C. 82% D. 70%

19. The limiting reagent in a chemical reaction is one that: C

A. has the largest molar mass B. has the smallest coefficient.

C. is consumed completely D. is in excess

20. How many mL of 17 M NH_3 must be diluted to 500.0 mL to make a 0.75 M solution? B

A. 13 mL B. 22 mL C. 39 mL D. 73 mL

21. When we light from a Neon sign, we are observing radiation from excited Neon atoms. If this radiation has a wavelength of 600 nm. What is the energy of the photon being emitted? B

A. 3.18×10^{-19} J B. 3.31×10^{-19} J C. 3.13×10^{-19} J D. 4.13×10^{-19} J

22. What is the maximum number of electrons that can occupy a shell with n=4 C

A. 50 B. 48 C. 32 D.44

23. Which of the following is **not** true B

A. The energy of atomic orbitals increases as the principal quantum number, n, increases

B. The energy of the orbitals increases within a shell in the order s<p<d<f

C. The increasing n value has more influence on energy than the increasing l value for small atoms

D. For larger atoms, the 4s orbital is higher in energy than the 3d orbital

24. What is the energy (in joules) of the line in the spectrum of hydrogen that represents the movement of an electron from Bohr orbit with n = 4 to the orbit with n = 6? B

A. 8.566×10^{-2} J B. 7.566×10^{-2} J C. 9.566×10^{-2} J D. 8.66×10^{-2} J

25. What is the formal charge of **N** atom in $\mathbf{NCl_3}$? D

A. -2 B.+2 C. +1 D.0

26. From the following alternatives which one has the **lowest** bond energy? C

A. F-Cl B. F-Br C. Si-Si D. Si-P

27. Which of the following is correct order of electron-pair repulsions from greatest to least repulsion B

A. Lone pair-bonding pair > Lone pair-lone pair >bonding pair-bonding pair

B. Lone pair-lone pair>lone pair-bonding pair>bonding pair-bonding pair

C. Lone pair-lone pair> bonding pair-bonding pair > lone pair-bonding pair

D. Bonding pair-bonding pair >lone pair-bonding pair> Lone pair-lone pair

28. From their positions in the periodic table, which of the following series is **correct** in order of increasing electronegativity C

A. C < F< H< O B. C < O <F< H C. H < C< O< F D. C < H <F< O

29. In the following reaction

N_2O_4 (g)⇌$2NO_2$(g), which of the following is the **correct** relationship between K_c and K_p A

A. $K_p= K_c(RT)$ B. $K_p= K_c(RT)^{-1}$ C. $K_c = K_p\,(RT)$ D. $K_p= K_c(RT)^2$

30. Which of the following is **wrong** when we increase the pressure on a system in which [C] NO, O_2, & NO_2 are at equilibrium in the following reaction?

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

A. The formation of additional amounts of NO_2 decreases the total number of molecules

B. The equilibrium shifts to the right

C. The equilibrium shifts to the left

D. The amount of NO and O_2 decreases while that of NO_2 increases

Part II. Match the following and write the letter of your choice inside the shaded region. (4 pts)

	Column A	Column B
1. [E]	Isotope	A. Trigonal pyramid
2. [C]	Oxyacids	B. Trigonal bipyramidal
3. [B]	PF_5 electron pair geometry	C. Compounds that contain Hydrogen, Oxygen and at least one other element
4. [D]	BF_3 electron pair geometry	D. Trigonal planar
		E. the same number of protons but different numbers of neutrons
		F. the same number of protons but different numbers of electrons

Part III. Fill in the blank spaces and write your answer in the blank space provided. (6 pts)

1. Extensive property is a property that depends on the amount of matter present.
2. The number 85.6 μm when written in the scientific notation is 8.56×10^{-5} m.
3. Frequency is the number of wave cycles that pass a specified point in space in a specified amount of time.
4. The tendency of main group atoms to form enough bonds to obtain eight valence electrons is known as the octet rule.
5. VSEPR theory enables us to predict the molecular structure, including approximate bond angles around a central atom, of a molecule from an examination of the number of bonds and lone electron pairs in its Lewis structure.
6. An electron in an atom is completely described by four quantum numbers:
   1) principal quantum number (n)
   2) azimuthal quantum number (l)
   3) orientation quantum number (m_l)
   4) spin quantum number (m_s)

Part IV. Show the necessary steps for the following questions and write your answer in the space provided.

1. Balance the following reaction that took place in acidic media. **(3 pts)**

$\overset{+7}{Mn}\overset{-2}{O_4}^- + \overset{+1}{C}\overset{-2}{H_3}\overset{+1}{O}\overset{-2}{H} \longrightarrow \overset{+1}{C}\overset{-2}{H_3}\overset{+1}{C}\overset{-2}{O}\overset{+1}{O}\overset{-2}{H} + Mn^{2+}$

Oxidation:

$CH_3OH \longrightarrow CH_3COOH$

$2CH_3OH \longrightarrow CH_3COOH$

$2CH_3OH \longrightarrow CH_3COOH + 4H^+$

$2CH_3OH \longrightarrow CH_3COOH + 4H^+ + 4e^-$

↳ multiply by 5 to get equal e^-

$5(2CH_3OH \longrightarrow CH_3COOH + 4H^+ + 4e^-)$

$10CH_3OH \longrightarrow 5CH_3COOH + 20H^+ + 20e^-$

Reduction:

$MnO_4^- \longrightarrow Mn^{2+}$

$MnO_4^- \longrightarrow Mn^{+2} + 4H_2O$

$8H^+ + MnO_4^- \longrightarrow Mn^{+2} + 4H_2O$

$5e^- + 8H^+ + MnO_4^- \longrightarrow Mn^{+2} + 4H_2O$

multiply by 4 to get equal e^-.

$4(5e^- + 8H^+ + MnO_4^- \longrightarrow Mn^{+2} + 4H_2O)$

$20e^- + 32H^+ + 4MnO_4^- \longrightarrow 4Mn^{+2} + 16H_2O$

Oxidation: $10CH_3OH \longrightarrow 5CH_3COOH + 20H^+ + 20e^-$

Reduction: $20e^- + 32H^+ + 4MnO_4^- \longrightarrow 4Mn^{+2} + 16H_2O$

Net: $10CH_3OH + 4MnO_4^- + 12H^+ \longrightarrow 5CH_3COOH + 4Mn^{+2} + 16H_2O$

$\boxed{10CH_3OH + 4MnO_4^- + 12H^+ \longrightarrow 5CH_3COOH + 4Mn^{+2} + 16H_2O}$

2. One type of anaerobic respiration converts glucose ($C_6H_{12}O_6$) to ethanol (C_2H_5OH) and carbon dioxide (CO_2). If the molecular weight of glucose is 180 grams/mol and the molar mass of ethanol is 46 g/mol, how many grams of carbon dioxide are produced when 0.5 mol of glucose is digested via respiration? **(2 pts)**

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$

$0.5\ mol\ C_6H_{12}O_6 \times \frac{2\ mol\ CO_2}{1\ mol\ C_6H_{12}O_6} \times \frac{44\ g\ CO_2}{1\ mol\ CO_2} = 44\ g\ CO_2$

↑ mol ratio on the reaction

↑ molar mass of CO_2

2

3. The equilibrium constant for the decomposition of $PCl_5(g)$ into $PCl_3(g)$ & $Cl_2(g)$ is 0.0211. What are the equilibrium concentrations of PCl_5, PCl_3, and Cl_2 if the initial concentration of PCl_5 was 1.00 M? **(3 pts)**

$$PCl_{5(g)} \longrightarrow PCl_{3(g)} + Cl_{2(g)}$$

$$k_c = \frac{[PCl_3]\,[Cl_2]}{[PCl_5]} = 0.0211$$

$PCl_5(g)$	$\longrightarrow$	$PCl_3(g)$	+	$Cl_2(g)$
1 M		0		0
$-x$		$+x$		$+x$
$1-x$		x		x

$$k_c = \frac{(x)(x)}{(1-x)} = 0.0211$$

$$= \frac{x^2}{1-x} = 0.0211$$

$$x^2 = 0.0211 - 0.0211x$$

$$x^2 + 0.0211x - 0.0211 = 0$$

$$x = \frac{-0.0211 \pm \sqrt{(0.0211)^2 - 4(1)(0.0211)}}{2}$$

← This is equilibrium concentration of $PCl_3(g)$ and $Cl_2(g)$

Equilibrium concentration of PCl_5 $= 1 - x = 1 - \dfrac{-0.0211 \pm \sqrt{(0.0211)^2 - 4(1)(0.0211)}}{2}$

3

6

but $\sqrt{(0.0211)^2 - 4(0.0211)}$ is undefined, because

$(0.0211)^2 - 4(0.0211) < 0$.

x has no defined value.

Therefore, the equilibrium concentrations of $PCl_3(g)$, $Cl_2(g)$ and $PCl_5(g)$ are UNdefined.

4. Air-saturated water has a H_3O^+ concentration of 2.0×10^{-6} M caused by the dissolved CO_2. Calculate the pH of the solution at 25 °C. **(2 pts)**

$[H^+] = [H_3O^+] = 2.0 \times 10^{-6}\ M$

$pH = -\log[H^+] = -\left(\log[2 \times 10^{-6}]\right) = -\left(\log 2 + \log 10^{-6}\right)$

$= -\log 2 - \log 10^{-6}$

$= -\log 2 + 6$

$= \underline{(6 - \log 2)}$

2

2