Kwantlen Polytechnic University
CHEM 1110

SAMPLE FINAL EXAM 1

Time allowed: 3 hours

INSTRUCTIONS:

1. **All calculations must be shown in order to receive any credit.**
2. A periodic table will be given to you.
3. **Rough work should be done on the back of the pages.**
4. Be sure this exam paper has 11 pages.
5. If you need more space, use the back of the preceeding page and clearly indicate the question number to be graded.

ADDITIONAL INFORMATION:

Avogadro's number = 6.02×10^{23} 1 atm = 760 mm Hg

K = 273 + °C R = 0.08206 L·atm/mol·K

$h = 6.626 \times 10^{-34}$ Joule·s and $c = 2.998 \times 10^{8}$ m/s

Page	Possible marks	
2	13	
3	14	
4	28	
5	20	
6	14	
7	12	
8	16	
9	28	
10	12	
11	15	
TOTAL	172	

1. **(5 marks)** What is the molecular weight of a gas if a 250 mL sample of this gas collected over water at 735 mm Hg and 28.0°C has a mass of 1.25 gram? The equilibrium vapor pressure of water at 28.0°C is 28.3 mm Hg.

2. **(3 marks)** A certain gas X is of unknown molecular mass. Under certain conditions of temperature and pressure this gas effuses through a pinhole at a rate of 16.60 mL in 10 minutes. At the same temperature and pressure argon effuses through the same pinhole at a rate of 15.0 mL in 5 minutes. Determine the molecular mass of gas X.

3. **(5 marks)** A sample of a sulfide of a metal M, (formula M_xS_y), is submitted to analysis to identify the metal. The sulfur in the sample is recovered as 120 mL of 0.250 M Na_2S solution. The metal in the same sample is recovered as 40.0 mL of 0.500 M solution of the metal ion.

   a. Find the formula M_xS_y of this metal sulfide. **(3)**

   b. The molar mass of this sulfide is 150 g/mole. Identify the metal **(show calculations.)(2)**

4. **(6 marks)** Consider the reaction

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(\ell)$$

Suppose 6.00 L of NH_3 measured at 25.0°C and 1.00 atm is mixed with 7.00 L of O_2, measured at the same temperature and pressure, and the above reaction takes place.

a. Identify the limiting reactant **(Show calculations.) (2)**

b. What is the mole fraction of the excess reactant in the gas mixture after the reaction has taken place? **(3)**

c. What is the partial pressure of the excess reactant in the same mixture if the total pressure of the mixture is adjusted to 0.400 atm.? **(1)**

5. **(8 marks)**

a. Write the ground state electronic configuration for $T\ell^{3+}$**. (2)**

b. How many unpaired electrons does $T\ell^{3+}$ (Thallium 3+) have in its ground state? **(1)**

c. Is $T\ell^{3+}$ in its ground state DIAMAGANETIC or PARAMAGNETIC? **(1)**

d. In the ground state electronic configuration of $T\ell^{3+}$ how many electrons have the following quantum numbers. **(4)**

(i) $n = 3$ ____

(ii) $n = 4$ and $\ell = 1$ ____

(iii) $m_\ell = +1$ ____

(iv) $m_\ell = +2$ and $m_s = +\frac{1}{2}$ ____

6. The Cℓ-Se-Cℓ bond angles in $\underline{Se}C\ell_4$ are expected to be approximately: **(2)**
A. 90° B. 109.5° C. 120° D. 180° E. 90° and 120°

7. According to the VSEPR theory, which of the following species is (are) predicted to be angular? **(2)**
A. $\underline{O}F_2$ B. $\underline{Xe}F_2$ C. O$\underline{C}$S D. H$\underline{C}$N E. both A and B

8. The central atom in $\underline{Br}F_2^+$ has __ bonding pair(s) and __ non-bonding (lone) pair(s). **(2)**
A. 2,0 B. 2,1 C. 2,2 D. 2,3 E. 3,2

9. According to VSEPR theory the geometry of the O$\underline{P}F_3$ molecule is best decribed as: **(2)**
A. tetrahedral B. see-saw C. square pyramid D. trigonal planar E. trigonal bipyramid

10. Which of the following molecules is polar? **(2)**
A. $\underline{C}C\ell_4$ B. $\underline{Ge}H_4$ C. $\underline{S}C\ell_4$ D. $\underline{Ga}I_3$ E. $\underline{S}O_3$

11. Which one of the following species has sp^2 hybridization at the central atom? **(2)**
A. $\underline{Br}F_2^{1-}$ B. $\underline{S}F_3^+$ C. $\underline{P}C\ell_3$ D. CH_3^+ E. CH_3^{1-}

12. Which of the following molecules has (have) sp^3d hybridization at the central atom? **(2)**
A. $\underline{Br}F_2^{1-}$ B. $\underline{S}F_3^+$ C. $\underline{P}C\ell_3$ D. CH_3^+ E. CH_3^{1-}
F. A and B G. A and C H. A and D I. B and E J. C and D

13. How many sigma(σ) and pi(π) bonds are there in the molecule $H_2\underline{CCC}H_2$? **(2)**
A. 6 σ B. 8 σ C. 2 σ and 2 π D. 4 σ and 4 π E. 6 σ and 2 π

14. The ground state molecular orbital electron configuration of the molecule C_2 is: **(2)**
A. $(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^1(\pi_{2p})^1$
B. $(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2$
C. $(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^2$
D. $(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p})^2(\pi_{2p})^2$
E. $(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p})^2(\pi^*_{2p})^2$

15. Use MO theory to predict which of the following is (are) paramagnetic? **(2)**
A. C_2 B. FN C. NO^+ D. A and B E. A and C

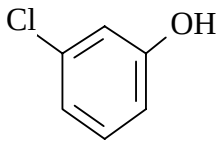
16. Use MO theory to predict which of the following species would have the shortest bond length? **(2)**
A. OF B. CN^- C. O_2^+ D. BO E. B_2

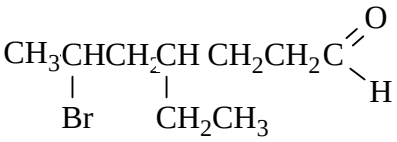
17. Use MO theory to predict which of the following species would have the longest bond length? **(2)**
A. OF B. CN^- C. O_2^+ D. BO E. B_2

18. Use MO theory to predict which of the following species would have the largest bond energy? **(2)**
A. OF B. CN^- C. O_2^+ D. BO E. B_2

19. Use MO theory to predict which of the following species would have the smallest bond energy? **(2)**
A. OF B. CN^- C. O_2^+ D. BO E. B_2

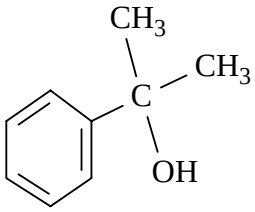
20. **(10 marks)** Name the following, using IUPAC or other acceptable names:

a. 

b. 

c. $CH_3CH_2C{\equiv}CC(CH_3)_3$

d. $CH_3CH_2CH_2COOH$

e. 

21. **(10 marks)** Draw structures for the following:

a. *cis*-3,4-dichlorocyclopentanone

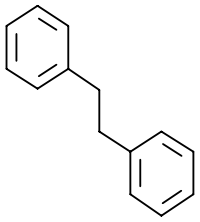
b. isobutyl benzoate **or** 2-methylpropyl benzoate

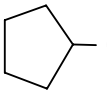
c. 2,4-dinitroethylbenzene

d. 3,5,5-trimethyl-4-propylnonane

e. *trans*-4,4-dimethyl-6-isopropyl-2-octene

22. **(14 marks)** Draw the structure(s) for the organic product(s) in each case.

(a)  + Br_2 (1 mol per mol) $\xrightarrow{\text{heat}}$

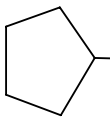
(b) $(CH_3)_2CHCOOH$ +  CH_2OH $\xrightarrow{H^+}$

(c) $CH_3-\underset{\underset{O}{\|}}{C}-CH_2-CH_2-\underset{\underset{O}{\|}}{C}-H$ + H_2(excess) $\xrightarrow{Pt}$

(d) $CH_3C(CH_3)=CHCH_2CH_3$ + HCl $\longrightarrow$

(e) $CH_3C(CH_3)=CHCH_2CH_3$ + $KMnO_4$ (hot) $\longrightarrow$

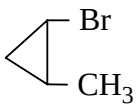
(f) $CH_3-\overset{\overset{OH}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_2-CH_2-\overset{\overset{OH}{|}}{\underset{\underset{H}{|}}{C}}-CH_3$ + $KMnO_4$ $\longrightarrow$

(g) $(CH_3)_2CHCOOH$ +  NH_2 $\xrightarrow{\text{heat}}$

23. **(6 marks)** For each compound, if *cis-trans* isomerism is possible draw the isomers, and if optical isomerism is possible label all chiral (asymmetric) carbon atoms with an asterisk (*).

(a) $C\ell CH=CHCH_3$

(b) $CH_2=CHCHC\ell CH_3$

(c) 

24. **(6 marks)**

a. Fog lights are effective for driving under foggy conditions because reflection is minimized since the wavelength of the yellow light is nearly equal to the diameter of a fog particle. A particular filament arrangement in fog lights generates a photon having an energy of 3.40×10^{-19} Joule. Estimate the diameter of a fog particle (in centimeters).**(2)**

b. For H-like species the energy of an electron in any given orbit can be calculated from the formula,

$$E_n = \frac{-2.178 \times 10^{-18} Z^2}{n^2} \text{ (Joule)}$$

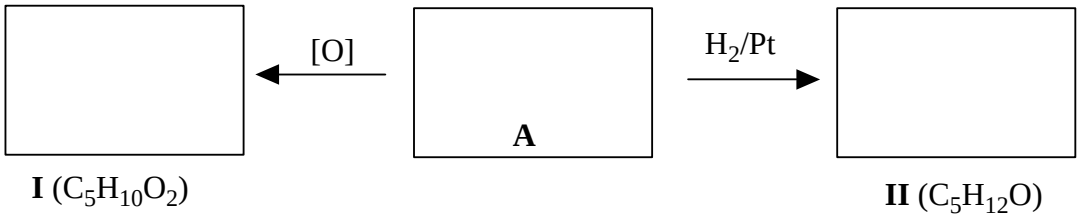
Calculate the wavelength and frequency of the photon produced for the transition from the n=4 to n=3 transition in the N^{6+} ion.**(4)**

25. **(16 marks)**

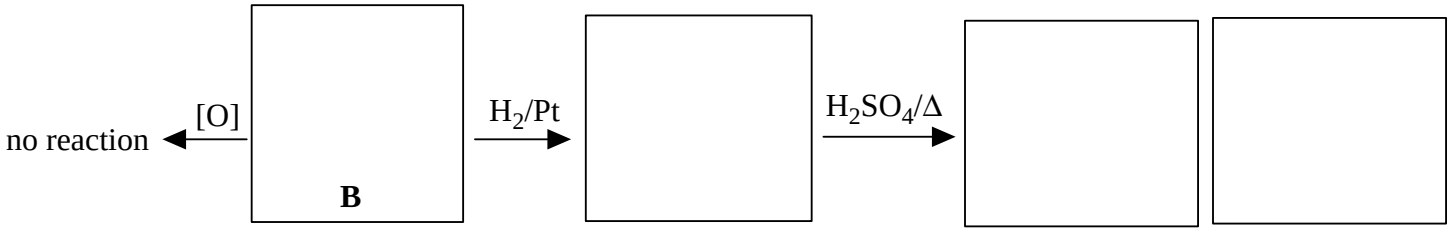
a. Draw the **7** isomers of $C_5H_{10}O$ which have a ketone or aldehyde functional group.**(7)**

b. Assign structures to **A**, **B** and **C**, three of the seven isomers referred to in part (a), and to their numbered reaction products (**I** to **VII**) on the basis of the data given below. ([O] = reaction with $KMnO_4$/heat).**(9)**

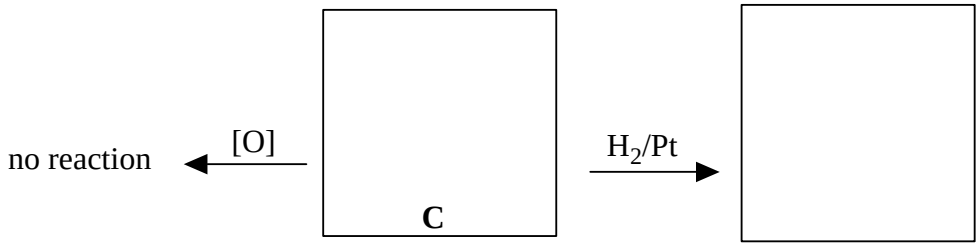
A has optical isomers but **B** and **C** do not. **A** gives a silver mirror with the Tollens reagent but **B** and **C** do not.



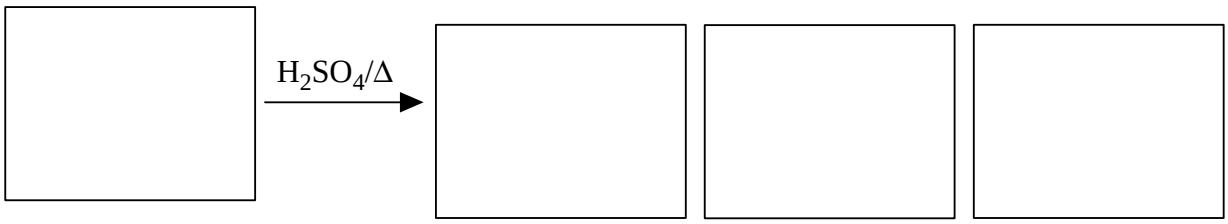
I ($C_5H_{10}O_2$) **II** ($C_5H_{12}O$)



III ($C_5H_{12}O$; optically inactive)



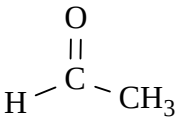
IV ($C_5H_{12}O$; optically active)



IV

V, **VI** and **VII** (C_5H_{10})

26. **(4 marks)** Indicate the type(s) of intermolecular forces present in each of the following liquids: **WILL BE MARKED RIGHT MINUS WRONG.**

SUBSTANCE	H-bonding	Dipole-Dipole	London or dispersion forces
			
fluoromethane			
cyclohexanol			
trimethylamine			

27. **(24 marks)** For each case, match the correct properties with the correct atom, ion, molecule, etc.:

a. Atomic radius (pm) 74, 118, 197

Si _____ Ca _____ O _____

b. Ionic radius (pm) 99, 133, 181

K^+ _____ Ca^{2+} _____ Cℓ _____

c. Electronegativity 1.6, 1.8, 2.2

Ga _____ Tℓ _____ S _____

d. Ionization energy (kJ/mol) 1145, 2081, 3388

O^{+1} _____ Ne ____ Ca^{+1} _____

e. Electron affinity (kJ/mol) -325, -195, -121

Sn _____ Se _____ Br _____

f. Ionization energy (kJ/mol) 550, 1012, 2080

Sr _____ Ne _____ P _____

g. Dipole moment (D) 0.00 (least polar), 0.25, 1.47 (most polar)

NF_3 _____ NH_3 _____ SF_6 _____

h. Bond length (pm) 92, 135, 175

C-F _____ H-F _____ N-Cℓ _____

28. Which compound has the highest boiling point? (**2**)
A. CH_3CH_3 B. CH_3OH C. CH_3CH_2CHO D. $HOCH_2CH_2OH$ D. $CH_3C\ell$

29. Which compound has the lowest boiling point? (**2**)
A. CH_3CH_3 B. CH_3OH C. CH_3CH_2CHO D. $HOCH_2CH_2OH$ D. $CH_3C\ell$

30. **(8 marks)** The metal scandium (Sc) was predicted to occur by Mendeleev before it was discovered in 1879. Determine the empirical formula of scandium hydroxide from the following data. A 0.3750 g sample of scandium hydroxide was reacted with 25.00 mL of 2.000 *M* HCl (excess reagent). The resulting solution was quantitatively transferred to a 500.0 mL volumetric flask and diluted to the mark with distilled water. A 20.00 mL sample from the volumetric flask required 15.30 mL of 0.1000 *M* NaOH solution.

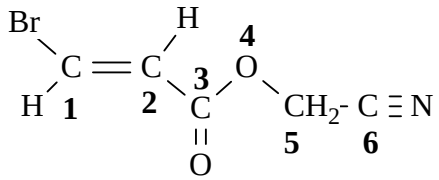
31. **(12 marks)** Draw the Lewis structure for each the following: **include formal charges and three non-equivalent resonance structures (label the "best"). (central atoms are underlined.)**

a. $\underline{Br}O_3^{1-}$

b. $O_2\underline{NN}O$

c. $C\underline{N}S^-$

32. **(3 marks)** Give the hybridization for each of the atoms numbered **1** to **6** in the molecule below.



1. _____ 2._____ 3._____ 4._____ 5._____ 6._____