Kwantlen Polytechnic University
CHEM 1110

SAMPLE FINAL EXAM 2

Time: 3 hours

INSTRUCTIONS:

1. Show all calculations 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 10 pages.

ADDITIONAL INFORMATION:

R = 0.08206 L-atm/mol-K
Planck's constant = h = 6.62×10^{-34} Joule-s
speed of light = c = 3.0×10^{8} m/s
Avogadro's number = 6.02×10^{23}
1 atm = 760 mm Hg

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10	**9**	
Bonus	**5**	
TOTAL	**155**	

1. **(5)** A sample of solid [$(NH_4)_2Fe(SO_4)_2 \cdot XH_2O$] of mass 5.882 g was dissolved in water and oxidized completely by reacting with exactly 25.00 mL of 0.1000 *M* $K_2Cr_2O_7$ according to the balanced net ionic equation shown below:

$$6Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \rightarrow 6Fe^{3+}(aq) + 2Cr^{3+}(aq) + 7H_2O$$

Determine the value of X in [$(NH_4)_2Fe(SO_4)_2 \cdot XH_2O$].

2. **(2)** A 1.520 g sample of a nitrogen oxide was found to contain 0.463 g of nitrogen. The empirical formula for this oxide of nitrogen is:
(a) N_2O (b) NO (c) N_2O_3 (d) NO_2 (e) N_2O_5

3. **(2)** 12.21 g of an unknown gas is sealed in a 1.0 L flask at 97°C and 3.75 atm. Which one of the following is most likely to be the unknown gas?
(a) H_2S (b) HBr (c) CO_2 (d) $COCl_2$ (e) C_2H_2

4. **(2)** Calculate the density in g/L of H_2S gas at 20°C and 0.80 atm pressure.
(a) 0.60 (b) 1.13 (c) 16.6 (d) 46.0 (e) 2.17

5. **(2)** Calculate the wavelength of photons having an energy of 180 kJ/mol.
(a) 6.64×10^{-13} nm (b) 3.98×10^{26} nm (c) 1.10×10^{-21} nm
(d) 664 nm (e) 6.64×10^{-7} nm

6. **(2)** How many orbitals in an atom can have n = 5?
(a) 5 (b) 9 (c) 10 (d) 25 (e) 50

7. **(2)** How many electrons in the ground state of a Hg atom can have the quantum number $m_\ell = +1$?
(a) 8 (b) 10 (c) 12 (d) 14 (e) 16

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

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

(a) **(4)** Calculate the energy and frequency for the transition from the n = 3 to n = 2 transition in the Li^{2+} ion.

(b) **(4)** Calculate the ionization energy (in kJ/mol) for the He^+ ion if the electron is in the ground state.

9. **(3)** Consider the electronic transitions in the H-atom from the n = 6 orbit to <u>all</u> the lower orbits in answering the following questions:

(a) The transition from n = _____ to n = _____ should produce the photon with the greatest frequency.

(b) The transition from n = _____ to n = _____ should produce the photon with the smallest frequency.

(c) The transition from n = _____ to n = _____ should produce the photon whose wavelength is most likely found in the visible region.

10. **(2)** Which element has the following valence electron configuration $6s^2 6p^2$?
(a) Sn (b) Sb (c) Pb (d) Bi (e) Te

11 **(2)** How many unpaired electrons does a Mn^{3+} ion have?
(a) 5 (b) 4 (c) 3 (d) 2 (e) 1

12. **(2)** The phosphide ion P^{3-} is isoelectronic with which one of the following?
(a) O^{2-} (b) F^- (c) Na^+ (d) Al^{3+} (e) K^+

13. **(2)** Which element has the smallest atomic radius?
(a) F (b) Al (c) S (d) P (e) Si

14. **(2)** Which ion has the smallest radius?
(a) Na^+ (b) K^+ (c) Ca^{2+} (d) Mg^{2+} (e) F^-

15. **(2)** Which of the following atoms would have the most negative electron affinity value?
(a) Ar (b) Cl (c) Br (d) K (e) P

16. **(2)** Which element will have the smallest first ionization energy?
(a) Li (b) Ga (c) K (d) Bi (e) As

17. **(2)** Which element has the highest electronegativity?
(a) As (b) Cl (c) Ga (d) P (e) Br

18. **(2)** Which element will have the largest second ionization energy?
(a) Li (b) Mg (c) O (d) S (e) Ca

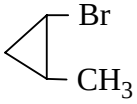
19. **(2)** Which of the following covalent bonds is the most polar?
(a) Al-I (b) Si-I (c) Al-Cl (d) Si-Cl (e) Si-P

20. 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 (*).

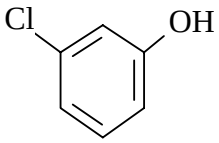
(a)**(2)** $ClCH{=}CHCH_3$

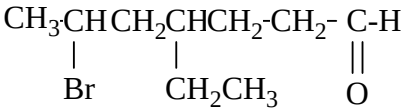
(b)**(1)** $CH_2{=}CHCHClCH_3$

(c)**(3)**

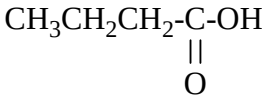


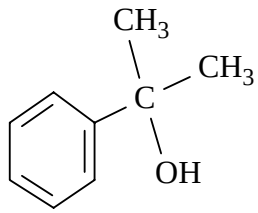
21. **(10)** Name the following, using IUPAC or other acceptable names:

(a) 

(b) 

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

(d) 

(e) 

22. **(10)** Draw structures for the following:
(a) *cis*-3,4-dichlorocyclopentanone

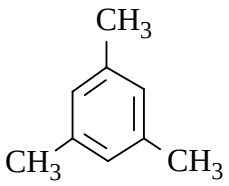
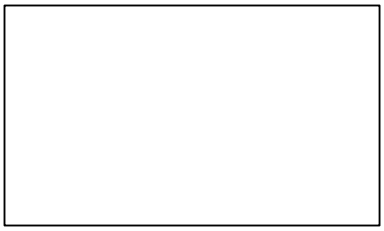
(b) isobutyl benzoate *or* 2-methylpropyl benzoate

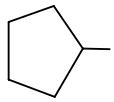
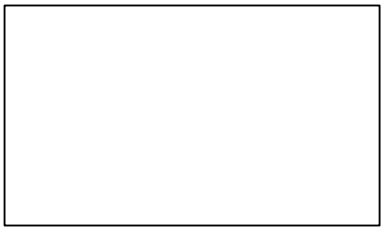
(c) 2,4-dinitroethylbenzene

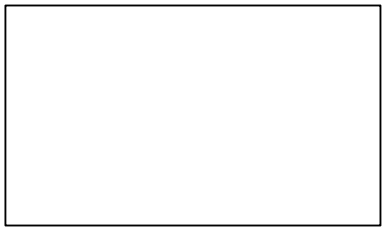
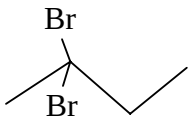
(d) 3,5,5-trimethyl-4-propylnonane

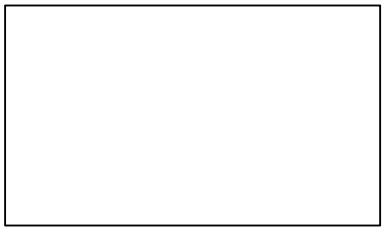
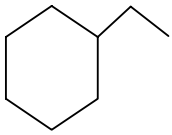
(e) *trans*-4,4,7-trimethyl-6-ethyl-2-octene

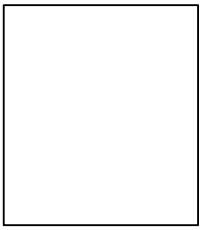
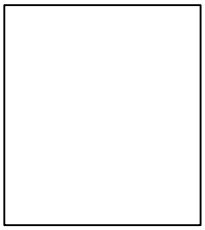
23. **(14)** Draw the structure(s) for the organic reactant(s) *or* product(s) in each case.

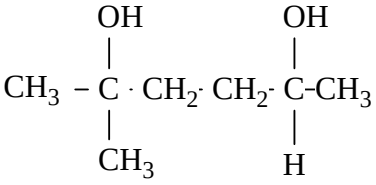
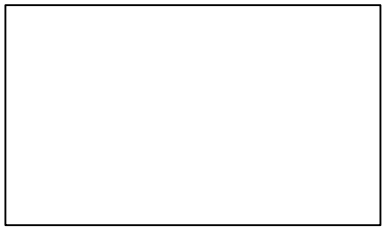
(a)  + Br_2 (1 mole) $\xrightarrow[\text{or } FeBr_3]{Fe}$ 

(b) $(CH_3)_2CHOH$ +  $\xrightarrow{H^+}$ 

(c)  + 2HBr $\longrightarrow$ 

(d)  + $2H_2$ $\xrightarrow{Pt}$ 

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

(f)  + $KMnO_4$ $\longrightarrow$ 

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

(b)**(7)** Assign structures to **A**, **B** and **C**, three of the isomers referred to in part (a), and to their numbered reaction products (**I** to **IV**) on the basis of the data given below. ([O] = reaction with $KMnO_4$ and [R] = reaction with H_2 and Pt).

A is optically active but **B** and **C** are not. **A** gives a silver mirror with the Tollens reagent but **B** and **C** do not.

I ($C_5H_{10}O_2$) $\xleftarrow{[O]}$ **A** $\xrightarrow{[R]}$ **II** ($C_5H_{12}O$)

no reaction $\xleftarrow{[O]}$ **B** $\xrightarrow{[R]}$ **III** ($C_5H_{12}O$; optically inactive)

no reaction $\xleftarrow{[O]}$ **C** $\xrightarrow{[R]}$ **IV** ($C_5H_{12}O$; optically active)

25. **(2)** According to the VSEPR theory the geometry of the $TlCl_3$ is best described as:
(a) trigonal pyramidal (b) trigonal planar
(c) tetrahedral (d) T-shaped
(e) square planar

26. **(2)** According to the VSEPR theory the geometry of the Cl_3AsO molecule is best described as**:**
(a) square planar (b) see-saw shaped
(c) trigonal bipyramidal (d) tetrahedral
(e) square pyramidal

27. **(2)** The bond angle in O_3 is expected to be approximately:
(a) 90° (b) 120° (c) 145° (d) 180° (e) 109.5°

28. **(2)** According to the VSEPR theory, the Cl-Se-Cl bond angles in the $SeCl_4$ molecule are predicted to be:
(a) 109.5° (b) 90° and 120° (c) 180° (d) < 109.5° (e) < 90° & < 120°

29. **(2)** What is the hybridization on the central atom in the SO_3^{2-}ion?
(a) sp (b) sp^2 (c) sp^3 (d) sp^3d (e) sp^3d^2

30. **(2)** What is the hybridization on the central atom in $SnCl_3^+$?
(a) sp (b) sp^2 (c) sp^3 (d) sp^3d (e) sp^3d^2

31. **(2)** Which one of the following is a polar molecule?
(a) AsF_5 (b) $GeCl_4$ (c) $GaCl_3$ (d) XeO_4 (e) SF_4

32. **(2)** What is the bond order for N_2^+?
(a) 0.5 (b) 1.0 (c) 1.5 (d) 2.0 (e) 2.5

33. **(2)** What is the bond order for O_2^{2-}?
(a) 1.0 (b) 1.5 (c) 2.0 (d) 2.5 (e) 3.0

34. **(2)** Which of the following is paramagnetic?
(a) H_2 (b) Li_2 (c) B_2 (d) C_2 (e) C_2^{2-}

35. **(2)** Which of the following would have the shortest bond length?
(a) O_2 (b) O_2^+ (c) O_2^- (d) O_2^{2-}

36. **(2)** Which of the following would have the largest bond energy?
(a) O_2 (b) O_2^+ (c) O_2^- (d) O_2^{2-}

37. **(2)** How many sigma and pi bonds are there in a molecule of NCCN?
(a) 3 sigma bonds (b) 3 sigma bonds and 2 pi bonds
(c) 4 sigma and 2 pi bonds (d) 4 sigma and 3 pi bonds
(e) 3 sigma and 4 pi bonds

38. **(4)** The measured O-N-O bond angles are 180° in NO_2^+, 134° in NO_2, adn 115° in NO_2^-. Account for this trend.

39. **(2)** Assume that you have an unlabeled bottle containing a white crystalline powder. The powder melts at 310°C. You are told that it is either, SO_3, CCl_4, BrCl, or $NaNO_3$. Which do you think that it is? Explain your choice.

40. **(6)** Write the Lewis dot structures, including formal charges as well as resonance forms as requested for each of the following:
(a) HPO_3^{2-} (show three resonance structures and circle the most probable)

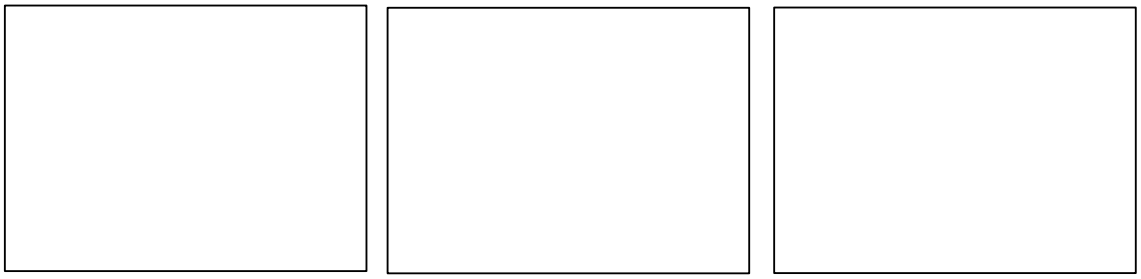
(b) $FClO_3$ (show three resonance structures and circle the most probable)

41. **(6)** There are more than 150 isomers of $C_6H_{10}O$. Give one possible structure for **A,** one for **B,** and one for **C** having the formula $C_6H_{10}O$ which give the following reactions:

$$C_6H_{12}O \xleftarrow{H_2 / Pt} \mathbf{A} \xrightarrow{Na\ (s)} H_2(g) + Na^+\ C_6H_9O^-$$

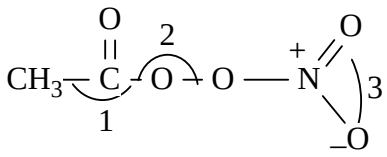
$$\text{no reaction} \xleftarrow{H_2 / Pt} \mathbf{B} \xrightarrow{Na\ (s)} H_2(g) + Na^+\ C_6H_9O^-$$

$$\text{no reaction} \xleftarrow{H_2 / Pt} \mathbf{C} \xrightarrow{Na\ (s)} \text{no reaction}$$



A **B** **C**

42. One of the constituents of photochemical smog is peroxyacetyl nitrate, PAN. It has the structure shown below.



(a) **(1)** How many sigma bonds are there in this molecule? _____

(b) **(1)** How many pi bonds are there in this molecule? _____

(c) **(3)** Give the approximate values of the angles labeled, 1,2,3.

Angle #1 _____ Angle #2 _____ Angle #3 _____

(d) **(1)** How many non-bonding (lone) pairs of electrons are in this structure? _____

(e) **(3)** Determine the number of atoms and the total number of hybrid orbitals used by these atoms in the above molecule.

Number of atoms using sp^3 hybrid orbitals is _____

Total number of sp^3 hybrid orbitals used is _____

Number of atoms using sp^2 hybrid orbitals is _____

Total number of sp^2 hybrid orbitals used is _____

Number of atoms using sp hybrid orbitals is _____

Total number of sp hybrid orbitals used is _____

BONUS QUESTION (5)

The bond angle H-O-H in water is 104.5°, the C-O-H bond angle in methanol is 109°, and the C-O-C bond angle in dimethyl ether is 112°. Explain the differences between the above observed bond angles and the expected bond angles.