NAME _____ Section (circle one): A/King or B/Madison

Chemistry 141
Final Exam
Fall 2018

This exam has 200 points total.
Part I. <u>Short Answer.</u> Answer 12 of the next 13 questions. You MUST cross out the one you wish not to be graded. 5 points each.

For each question, you must do both parts a and b.		
	Name	Chemical Formula
1a.		NF_3
1b.	Calcium carbonate	
2a.		NH_4Br
2b.	Magnesium sulfate heptahydrate	

3. Magnesium has 3 stable isotopes. What is the isotopic abundance of ^{24}Mg?

Isotope	Mass	Isotopic Abundance
^{24}Mg	23.98504 amu	?
^{25}Mg	24.98583 amu	10.00 %
^{26}Mg	25.98259 amu	11.01%

Isotopic abundance of ^{24}Mg: _____%

What is the atomic weight of Magnesium (show your work)?

_____g/mol

4. How many moles of PbO are produced from the reaction of 5.0 mol of PbS and 6.0 mol of O_2?

$$2\ PbS\ (s) + 3\ O_2\ (g) \rightarrow 2\ PbO\ (s) + 2\ SO_2\ (g)$$

_____moles PbO

5. What is the oxidation number of each element in $NaBiO_3$?

Na: _____ Bi:_____ O:_____

6. True or False:

_____A. When chemical bonds are broken, energy is released.

_____B. The phase change of liquid to solid, commonly called freezing, is exothermic.

_____C. The electrons in a molecule can be in an excited state if the molecule absorbed a photon.

_____D. If a substance absorbs red photons, it will appear red.

_____E. Heat (q) and work (w) are two examples of state functions.

7. Rank the following atoms or ions:

A. Increasing ATOMIC radius: O, F, Ga, Br

_____< _____< _____< _____

B. Increasing IONIC radius : Ti^{4+}, V^{5+}, Cl^-

_____< _____< _____

C. Increasing SECOND Ionization Energy: K, Ca, Sc

_____< _____< _____

8. Which of the following molecules have dipole-dipole interactions as an intermolecular force? Circle *all* correct answers.

A) ICl_4^-

B) PCl_5

C) ClF_3

D) SO_2

E) None of the above

9. Which of the following molecules has the molecular geometry known as T-Shaped? Circle *all* correct answers.

A) ClO_3^-

B) ClF_3

C) NF_3

D) IF_3

E) None of the above

10. How many total, angular, and radial nodes does a 4d orbital have?

Total nodes: _____ Angular nodes: _____ Radial nodes: _____

11. Which atom or ion has exactly 3 **unpaired** electrons? Circle *all* correct answers.

A) Cr^{3+}

B) P^+

C) Sc

D) V^{2+}

12. Adding the following compounds to water will increase the boiling point and decrease the freezing point. Assuming one mole of each is added to water, rank the compounds in terms of boiling point elevation (1 = highest to 3 = lowest)

_____ NaCl, _____ $MgCl_2$, _____ CH_3CH_2OH

13. Indicate if the following combinations will form a stable solution. Fill in the blank with the appropriate key term: soluble, insoluble, miscible, or immiscible.

_____ $Pb(NO_3)_2$ (s) in H_2O (l)

_____ CH_3OH (l) in NH_3 (l)

_____ NaCl (s) in CO_2 (l)

Part II. <u>Problems.</u> Answer 6 of the next 7 questions. You MUST cross out the one you wish not to be graded. 12 points each.

14. What is the **wavelength** of a photon that can excite an electron in a hydrogen atom from the 1s orbital to a 3d orbital? Report your answer in nanometers and with three significant digits.

15. What are the partial pressures of all gases when a 1.7 L ridged container of N_2O_5 at 0°C and 1.00 atm pressure decomposes completely into NO_2 (g) and O_2 (g)?

Unbalanced Reaction: N_2O_5 (g) → NO_2 (g) + O_2(g)

$P_{N_2O_5}$ _____
P_{NO_2} _____
P_{O_2} _____

16. In each list:
A. Circle which molecule has **the highest boiling point**. Explain why.

F_2 Br_2 Cl_2

Why? _____

B. Circle which molecule has **the highest vapor pressure**. Explain why.

CH_3CH_2OH CH_3COCH_3 $CH_3CH_2CH_3$

Why? _____

C. Circle which atom or molecule is **diamagnetic**. Explain why.

N_2 O_2 Al

Why? _____

17. An unknown compound contains *only* carbon, nitrogen, and hydrogen (and no oxygen). When the unknown is combusted completely with excess oxygen it produces 55.0 g of CO_2, 15.8 g of H_2O, and 23.0 g of NO_2. What is the empirical formula of the compound?

18. When the following solutions are mixed together, what precipitate (if any) will form? If no precipitate forms, indicate that fact.

A. $Al(NO_3)_3$ (aq) + $Ba(OH)_2$ (aq) →

B. Na_2SO_4 (aq) + $Pb(NO_3)_2$ (aq) →

C. KCl (aq) + NH_4Br (aq) →

19. What is the mass of $Ca(OH)_2$ (s) required to neutralize 12.0 mL of 3.50 M $HClO_4$ (aq)?

20. Given the following reactions,

Fe_2O_3 (s) + 3CO (g) → 2Fe (s) + $3CO_2$ (g) $\Delta H = -28.0$ kJ

3Fe (s) + $4CO_2$ (g) → 4CO (g) + Fe_3O_4 (s) $\Delta H = +12.5$ kJ

What is the enthalpy of the reaction of Fe_2O_3 with CO?

3 Fe_2O_3 (s) + CO (g) → CO_2 (g) + 2 Fe_3O_4 (s)

Part III. <u>Problems.</u> Answer 4 of the next 5 questions. You MUST cross out the one you wish not to be graded. 17 points each.

21. A. Using Lewis structures and resonance structures, which molecule has a higher bond order, NO_2^- or NO_3^-?

B. Using molecular orbital theory, which molecule has a higher bond order, NO or NO^-?
Draw the molecular orbital diagrams and indicate the electron filling. Hint: NO has a molecular orbital diagram similar to N_2.

C. Using molecular orbital theory, decide if OF is more likely to form an OF^+ ion or an OF^- ion
Draw the molecular orbital diagram and indicate the electron filling. Hint: OF has a molecular orbital diagram similar to O_2.

22. A. How much heat (in kJ) is required to convert a 100. cm^3 block of **ice** that has an initial temperature of -40.°C into liquid water at 0.0 °C? (Data: ΔH_{fus} = 6.01 kJ/mole, density (ice)=0.9340 g/cm^3, C_p (ice)= 2.1 J/g °C, C_p (water)= 4.2 J/g °C)

B. Using enthalpies of formation, would the combustion of 1.07 L of methane (g) at 1.00 atm of pressure and 25 °C provide enough heat to melt the 100. cm^3 block of **ice** that starts at -40.°C? Show your work.

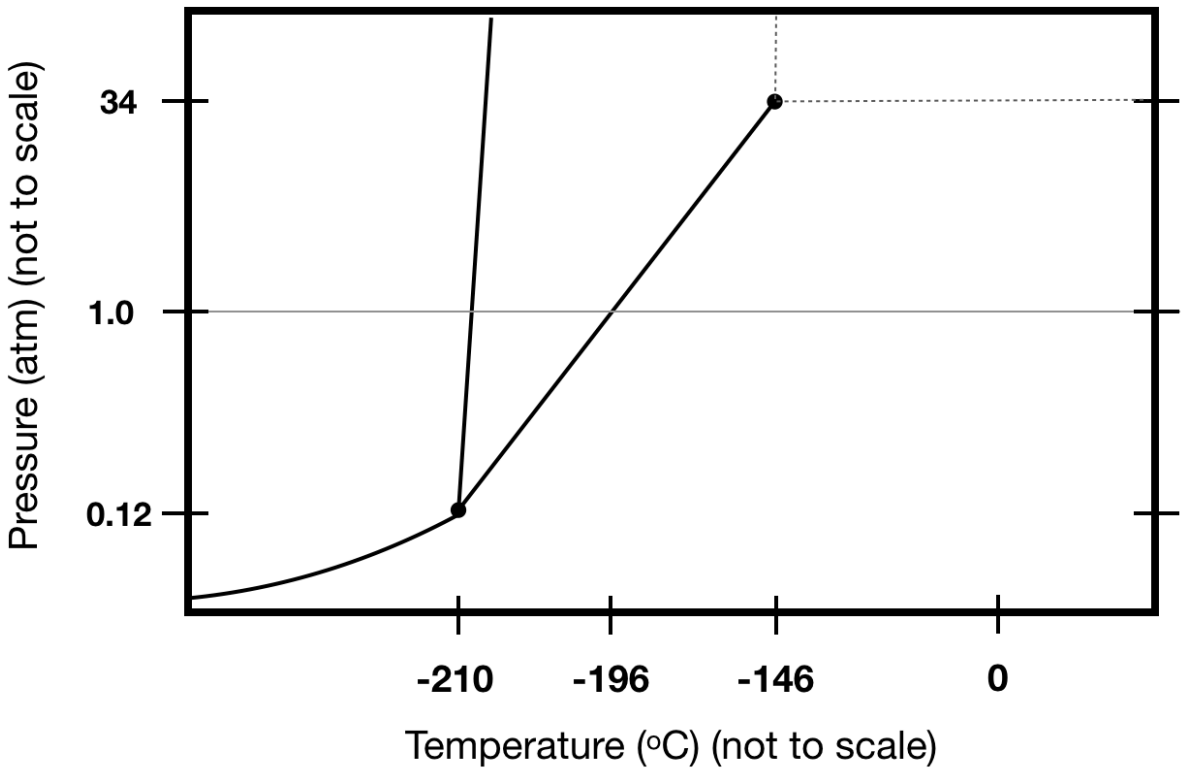
Substance	ΔH_f^o (kJ/mol)
CH_4 (g)	-75.0
H_2O (g)	-242
CO_2 (g)	-393.5

C. Using bond enthalpies, would the combustion of 1.0 g of acetylene (HCCH) provide enough heat to melt the 100. cm^3 block of **ice** that starts at -40.°C? Show your work.

Hint: Acetylene is a linear molecule with one hydrogen attached to each carbon.

Bond Type	C-H	C-C	O-H	C=O	C=C Double bond	C≡C Triple bond	O=O
Bond Enthalpy (kJ/mol)	413	348	463	799	614	839	495

23. Below is the phase diagram for N_2. The gray solid line at 1.0 atm is provided to help guide your eye.



A. Label the following 6 points on the graph. Label each region as either solid, liquid, gas, or super critical fluid. Label the triple point and the critical point.

B. What is the phase transition that happens at 1 atm of pressure as the temperature increases from -200 °C to 25 °C?

C. What is the minimum pressure necessary to create liquid N_2?

D. At 2.00 atm of pressure, which value is closest to the freezing temperature of N_2? Circle the best answer:

a) -211 °C b) -209 °C c) -192 °C d) -200 °C e) -140 °C

E. Label the phase diagram with a star (*) at the pressure and temperature conditions of this room. Define the P and T at this point.

24. Balance the following redox reaction using the methods of half reactions. Show your work.

A. $NH_3(g) + O_2(g) \rightarrow NO(g) + H_2O(g)$

B. Which reactant has been oxidized?

C. Which reactant has been reduced?

D. If 3.49 g of ammonia and 2.16 g of oxygen are allowed to react, what volume of nitric oxide is evolved at 273.2 K and 1.00 atm?

25. A solution of 5.00 g of lauryl alcohol in 0.100 kg of benzene freezes at 4.1°C. Calculate the molar mass of lauryl alcohol. K_f for benzene is 5.12 °C kg/mol and the normal freezing point of benzene is 5.5°C. Show all work.