

**Exam 4 Chm 203 (Dr Mattson) 12 November 2018**

**Academic Integrity Pledge:** *In keeping with Creighton University's ideals and with the Academic Integrity Code, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.*

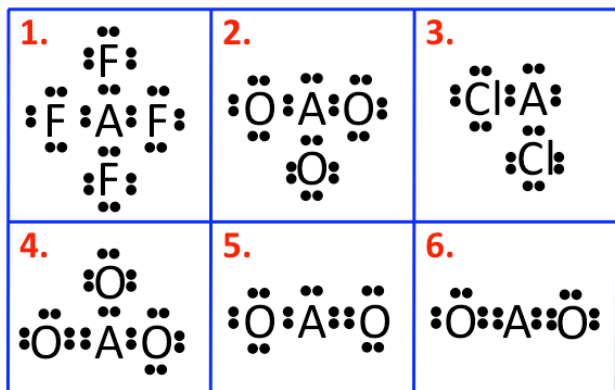
Signature: \_\_\_\_\_

Name: \_\_\_\_\_

**Chemistry Student Number:** \_\_\_\_\_  
(1 point bonus for completing 1. signature, 2. printed name and 3. your correct chemistry student number)

**Instructions:** Show all work whenever a calculation box is provided! Write legibly. Include units whenever appropriate. You will receive credit for **how** you worked each problem as well as for the correct answer. If you need more space, you may use the back of the data sheet provided — Write: "See data sheet" in the answer box — then write your name on the data sheet. On your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks, bags, and purse-like items must be stored on the tables in the back of the room. Cell phones must be silent and placed in your backpack/bag/purse — not in your pocket.

- (4 pts) Ballpark estimating...
  - What is a typical covalent single bond strength? **Circle one:** 5 kJ/mol 30 kJ/mol 300 kJ/mol 1000 kJ/mol
  - What is a typical covalent single bond length? **Circle one:** 5 mm 120 pm 60 μm 15 nm
  - Generally, how does ionic bonding compare to covalent bonding? **Circle A or B:** A. Ionic bonds are stronger or B. Covalent bonds are stronger
  - What is a typical range of values for intermolecular forces? **Circle one choice, A - D:** A. 1–40 J/mol B. 1–30 kJ/mol C. 30–90 kJ/mol D. 100–400 kJ/mol
- (4 pts) Circle the most polar covalent bond in each set.
  - C-C C-N C-F
  - As-O P-O F-O
  - F-Cl F-Br F-I
  - O-O O-Br Br-Br
- (4 pts) Which pair of atoms in each set is most likely to form covalent bonds?
  - aluminum and chlorine or boron and carbon
  - silicon and nitrogen or neon and hydrogen
  - hydrogen and hydrogen or iron and iron
  - lithium and hydrogen or sulfur and chlorine
- (12 pts) Consider these six structures to answer Questions 4, 5 and 6. F is fluorine and O is oxygen.



- What is the identity of the central element, A, in Figure 1 if A is B, C, N, O, F or Ne and if the structure has an overall +1 charge? **Circle one:** B, C, N, O, F or Ne
- What is the identity of A in Figure 2 if A is In, Sn, Sb, Te, I, or Xe and the structure is neutral? **Circle one:** In, Sn, Sb, Te, I, or Xe

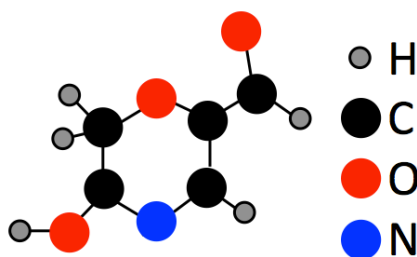
- What is the identity of A in Figure 3 if A is Ga, Ge, As, Se, Br, or Kr and if the structure has an overall -1 charge? **Circle one:** Ga, Ge, As, Se, Br, or Kr
  - What is the identity of A in Figure 4 if A is Al, Si, P, S, Cl or Ar and if the structure has a charge of -2. **Circle one:** Al, Si, P, S, Cl or Ar
  - What is the identity of A in Figure 5 if A is Ga, Ge, As, Se, Br, or Kr and the structure is neutral. **Circle one:** Ga, Ge, As, Se, Br, or Kr
  - What is the identity of the A in Figure 6 if A is B, C, N, O, F or Ne and has a +1 charge. **Circle one:** B, C, N, O, F or Ne
- (12 pts) This question also refers to the six figures presented in Question 4.
    - Which of the structures are polar **if all are neutral?** (The identities of A may not be the same as they were in Question 4) **Circle all that apply:** 1 2 3 4 5 6
    - Which of the structures feature sp<sup>2</sup> hybridization? **Circle all that apply:** 1 2 3 4 5 6
    - Which of the structures feature resonance? **Circle all that apply:** 1 2 3 4 5 6
    - Which of the structures have angles close to 109°? **Circle all that apply:** 1 2 3 4 5 6
    - Which of the structures are diamagnetic? **Circle all that apply:** 1 2 3 4 5 6
    - Which of the structures are described as bent? **Circle all that apply:** 1 2 3 4 5 6

- (6 pts) How many σ- and π-bonds are present in Figures 3, 4, 5 and 6, and what is the shape name of the structure? (for example, tetrahedral)

Figure	σ-bonds	π-bonds	Shape name
3			
4			
5			
6			

- (3 pts) Sketch one resonance form for the nitrate ion and assign formal charges to each atom. Write the formal charges near each atomic symbol.

8a. (4 pts) Add the electron pairs and the double bonds necessary to complete this sketch.



8b. (1 pt) Fill in with your pencil the H atom(s) that can hydrogen bond.

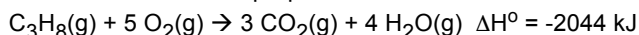
9. (7 pts) Expanded octet name matching.

- |                                      |                       |
|--------------------------------------|-----------------------|
| _____ AB <sub>5</sub>                | A. octahedron         |
| _____ AB <sub>4</sub> E              | B. square pyramid     |
| _____ AB <sub>3</sub> E <sub>2</sub> | C. T-shaped           |
| _____ AB <sub>2</sub> E <sub>3</sub> | D. square plane       |
| _____ AB <sub>6</sub>                | E. trigonal bipyramid |
| _____ AB <sub>5</sub> E              | F. linear             |
| _____ AB <sub>4</sub> E <sub>2</sub> | G. seesaw             |

10. (5 pts) Circle the species with the largest intermolecular forces in each group.

- 10a. Cl<sub>2</sub>    Br<sub>2</sub>    I<sub>2</sub>  
 10b. CH<sub>3</sub>OH    CH<sub>4</sub>    F<sub>2</sub>  
 10c. SH<sub>2</sub>    BH<sub>3</sub>    NH<sub>3</sub>  
 10d. Cl<sub>2</sub>    BrCl    Br<sub>2</sub>  
 10e. C<sub>2</sub>H<sub>4</sub>    C<sub>3</sub>H<sub>6</sub>    C<sub>4</sub>H<sub>8</sub>

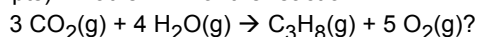
11. The combustion of propane is:



11a. (2 pts) Express  $\Delta H^\circ$  in terms of kJ/mol CO<sub>2</sub>(g).

Answer with units: \_\_\_\_\_

11b. (2 pts) What is  $\Delta H^\circ$  for the reaction:



Answer with units: \_\_\_\_\_

11c. (4 pts) What is the change in energy, q, if 2.721 g water are formed in the combustion of propane?

Show your work for full credit.

Answer with units: \_\_\_\_\_

12. (5 pts) Evaluate these as exothermic or endothermic.

- 12a. Heating water to a boil.                    **Exo**    **Endo**  
 12b. Formation of snow in a cloud.            **Exo**    **Endo**  
 12c. Sugar burning.                                **Exo**    **Endo**  
 12d. Drops of water condensing.               **Exo**    **Endo**  
 12e. Baking bread.                                 **Exo**    **Endo**

13a. (4 pts) Suppose 5.00 g of NH<sub>4</sub>NO<sub>3</sub> (MM = 80.04 g/mol) was dissolved in 50.0 g water in a calorimeter. Calculate q<sub>cal</sub> if the final temperature is 6.99 degrees lower than the initial temperature and the specific heat for the solution is 4.18 J/g deg.

Show your work for full credit.

Answer with units: \_\_\_\_\_

13b. (4 pts) Calculate the molar heat of solution for NH<sub>4</sub>NO<sub>3</sub>,  $\Delta H^\circ$ , expressed in kJ/mol NH<sub>4</sub>NO<sub>3</sub>.



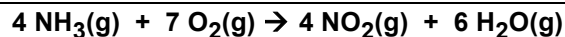
Show your work for full credit.

Answer with units: \_\_\_\_\_

14. (4 pts) Use the  $\Delta H_f^\circ$

data at right to calculate  $\Delta H^\circ$  for the reaction given in the box.

NH <sub>3</sub> (g)	$\Delta H_f^\circ = -46.1 \text{ kJ/mol}$
O <sub>2</sub> (g)	0
NO <sub>2</sub> (g)	+33.2
H <sub>2</sub> O(g)	-241.8



Answer with units: \_\_\_\_\_

15. (10 pts) Nomenclature. Complete each of these. Skip this question if you are nomenclature certified.

chromium(III) chlorate	
potassium dichromate	
dichlorine tetroxide	
bromic acid	
ammonium sulfate	
	K <sub>2</sub> O
	HNO <sub>3</sub> (aq)
	Mn(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>
	Li <sub>2</sub> CO <sub>3</sub>
	N <sub>2</sub> O

Total score (out of 100): \_\_\_\_\_

A+ ≥ 95%    A ≥ 90%    B+ ≥ 85%    B ≥ 80%    C+ ≥ 75%    C ≥ 70%    D ≥ 60%

## Answers

1a. 300 kJ/mol

1b. 120 pm

1c. **A.** Ionic bonds are stronger

1d. **B.** 1–30 kJ/mol

2a. C-F

2b. As-O

2c. F-I

2d. O-Br

3a. boron and carbon

3b. silicon and nitrogen

3c. hydrogen and hydrogen

3d. sulfur and chlorine

4a. **N**

4b. **Xe**

4c. **As**

4d. **Si**

4e. **Se**

4f. **N**

5a. 2 3 5

5b. 4 5

5c. 4 5

5d. 1 2 3

5e. 1 2 3 4 5 6

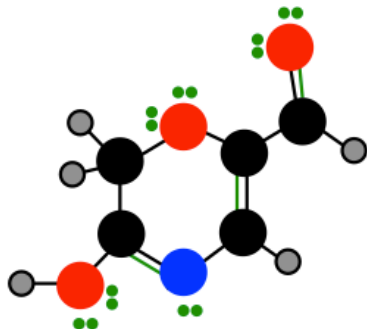
5f. 3 5

6.

Figure	$\sigma$ -bonds	$\pi$ -bonds	Shape name
3	2	0	Bent
4	3	1	Trigonal plane
5	2	1	Bent
6	2	2	Linear

7. Nitrate is  $AB_3$ . The two single-bonded oxygen atoms have FC = -1 and the double-bonded oxygen has FC = 0. Nitrogen has FC = +1

8a. Answers in green.



8b. The H-bonding hydrogen is the one bonded to the leftmost oxygen (lower left)

9. E G C F A B D

10a.  $I_2$

10b.  $CH_3OH$

10c.  $BH_3$

10d. BrCl

10e.  $C_4H_8$

11a.  $\Delta H^\circ = -681 \text{ kJ/mol } CO_2(g)$

11b.  $\Delta H^\circ = +2044 \text{ kJ}$

11c.  $q = -77 \text{ kJ}$

12. endo, exo, exo, exo, endo

13a.  $q = -1.6 \text{ kJ}$

13b.  $\Delta H^\circ = +25.6 \text{ kJ/mol } NH_4NO_3$ .

14.  $\Delta H_{rxn}^\circ = -1133 \text{ kJ}$

15.

chromium(III) chlorate	$Cr(ClO_3)_3$
potassium dichromate	$K_2Cr_2O_7$
dichlorine tetroxide	$Cl_2O_4$
bromic acid	$HBrO_3$
ammonium sulfate	$(NH_4)_2SO_4$
potassium oxide	$K_2O$
nitric acid	$HNO_3(aq)$
manganese(II) acetate	$Mn(C_2H_3O_2)_2$
lithium carbonate	$Li_2CO_3$
dinitrogen monoxide	$N_2O$