Exam 4 Chm 203 (Dr Mattson) 11 November 2019

Name:

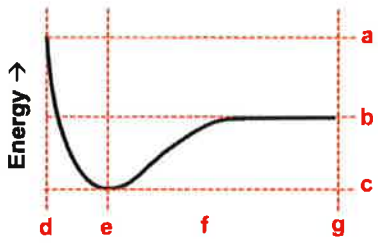
Academic Integrity Pledge: *In keeping with Creighton University's ideals and with the Academic Integrity Code, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.*

Signature:

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 periodic table provided — Write: "See PT" in the answer box. Write your name on the periodic table if it contains work to be graded. On your desk you may have pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks, bags, and similar items must be stored on the tables in the back of the room. Cell phones must be silent and placed in your backpack/bag – not in your pocket.

1a-b-c. (1 pt each) This diagram shows energy (y-axis) vs. internuclear distance (x-axis) for two hydrogen atoms making the hydrogen molecule, H_2.



1a. Draw an arrow pointing to where the two H atoms are far enough apart that there is no bonding interaction.

1b. What line represents the normal bond length for H_2, 74 pm? **Circle: a b c d e f g**

1c. What subtraction gives the bonding energy for H_2?

b – a c – b c – a e – d g – e

1d. (2 pts) The bond dissociation energy for hydrogen is 436 kJ/mol. Circle the two correct ΔE values.

i. $H_2 \rightarrow 2\ H$ **ΔE = +436 kJ** or **ΔE = -436 kJ**

ii. $2\ H \rightarrow H_2$ **ΔE = +436 kJ** or **ΔE = -436 kJ**

1e. (2 pts) Under the right conditions, the molecule Na_2 exists. What would you predict about its bond length and strength compared to H_2?

Its bond length would be **larger** or **smaller**

Its bond strength would be **larger** or **smaller**

1f. (2 pts) Sketch the energy diagram for Na_2 on top of the diagram above so that it can be compared to H_2.

2. (3 pts) Circle the most electronegative element in each set. a. **C O Ne** b. **N P As** c. **Ga Ge As**

3. (3 pts) Circle the most polar bond in each set.
a. **C – N** or **C – O** b. **N – N** or **P – O** c. **H – F** or **H – Cl**

4a. (8 pts) Sketch Lewis dot structures for each of these.

$AsCl_3$	CO_3^{2-}
NO_2^+	SeH_3^+

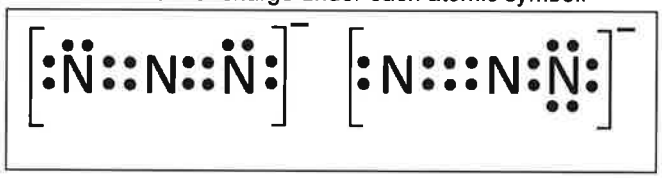
4b. (4 pts) What is the central atom hybridization for each?

$AsCl_3$	CO_3^{2-}
NO_2^+	SeH_3^+

4c. (4 pts) What is the shape name for each?

$AsCl_3$	CO_3^{2-}
NO_2^+	SeH_3^+

5a. (6 pts) The azide ion, N_3^-, is used in automobile air bags in the form of sodium azide. Assign formal charges to each atom in these two possible structures. Write the formal charge under each atomic symbol.



5b. (1 pt) From your drawing above, which structure is probably more important? **Circle: Left** or **Right**

6. (3 pts) Ozone has the formula O_3. Sketch its Lewis dot structure given that the molecule does not form a triangle of atoms – there is one central atom.

6b. (1 pt) Is ozone polar? **Circle: Yes** or **No**

6c. (1 pt) Does ozone have resonance? **Circle: Yes** or **No**

6b. (2 pt) How many ***total*** σ and π bonds are in ozone?

___ σ and ___ π

7a. (8 pts) Sketch each of these molecules/ions and write the shape name for each.

AsF_5 Shape:	ClO_2 Shape:
SeF_4 Shape:	PF_6^- Shape:

7b. (3 pts) Which is/are polar? **Circle: AsF_5 ClO_2 SeF_4**

7c. (1 pt) Which one is paramagnetic?

8. (4 pts) The basic structure of caffeine is shown here. Carbon is shown in black, oxygen in red, nitrogen in blue and hydrogen in white. Only single bonds are shown. Add bonds as needed to make every atom have an octet.

9. The mini-explosion we saw with the soap bubbles is

$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l) \quad \Delta H^o = -571\ kJ$$

9a. (1 pt) Is this reaction exothermic or endothermic?

9b. (4 pts) The reaction we saw involved about 0.25 mmol $H_2(g)$ with excess $O_2(g)$. How much heat, q, is released/absorbed during this mini-explosion?

Show all work for credit.

Answer with units and correct sign for q: _____

9c. (2 pts) What is ΔH for this version of the reaction:

$$H_2O(l) \rightarrow H_2(g) + \tfrac{1}{2}\ O_2(g) \quad \Delta H^o = ?$$

9d. (2 pts) Write the chemical equation for the standard heat of formation of $H_2O(l)$ and give its ΔH_f^o value

$\Delta H_f^o =$

10. (5 pts) The standard heats of formation for sulfur dioxide and sulfur trioxide are -250 kJ/mol SO_2 and -349 kJ/mol SO_3, respectively. Calculate ΔH^o for this reaction between SO_2 and O_2:

$$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g) \quad \Delta H^o =$$

Show all work for credit.

Answer with units: _____

11a. (4 pts) Suppose a piece of calcium with mass 1.012 g was added to a coffee cup calorimeter filled with 60.0 g water. The following reaction takes place and is rather vigorous:

$$Ca(s) + 2\ H_2O(g) \rightarrow Ca(OH)_2(aq)$$

The temperature of the calorimeter increased by 55.4 degrees. Calculate q_{cal}. ($c = 4.18\ J\ g^{-1}\ deg^{-1}$)

Show all work for credit.

Answer with units: _____

11b. (4 pts) Calculate ΔH for the reaction as given in 11a.

$$Ca(s) + 2\ H_2O(g) \rightarrow Ca(OH)_2(aq) \qquad \Delta H =$$

Answer with units: _____

12. (3 pts) Which of these reactions is/are exothermic?

a. boiling water: $H_2O(l) \rightarrow H_2O(g)$ ΔH is > 0 or <0

b. combustion of CH_4: ΔH is > 0 or <0

c. soda fizzing: $CO_2(aq) \rightarrow CO_2(g)$ ΔH is > 0 or <0

13. (4 pts) Given the table of bond dissociation energies, estimate ΔH for the reaction:

kJ/mol	H	N	Cl
H	436	390	432
N	390	240	200
Cl	432	200	243

$$NH_3(g) + Cl_2(g) \rightarrow HCl(g) + NH_2Cl(g)$$

14. (10 pts) Nomenclature. Complete the following table. (If you are nomenclature certified, skip this question.)

bromine pentafluoride	
manganese(II) phosphide	
vanadium(V) oxide	
arsenic trioxide	
potassium sulfite	
	$Cr(NO_3)_3$
	$(NH_4)_2CO_3$
	SiF_4
	B_3P_3
	$KHSO_4$

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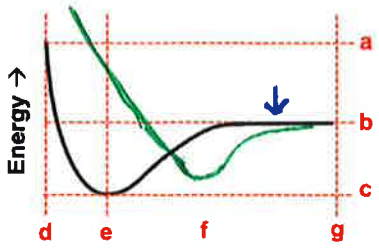


1a. Draw an arrow pointing to where the two H atoms are far enough apart that there is no bonding interaction.

1b. What line represents the normal bond length for H_2, 74 pm? **Circle:** a b c d (e) f g

1c. What subtraction gives the bonding energy for H_2?

b – a (c – b) c – a e – d g – e

1d. (2 pts) The bond dissociation energy for hydrogen is 436 kJ/mol. Circle the two correct ΔE values.

i. $H_2 \rightarrow 2\ H$ (ΔE = +436 kJ) or ΔE = -436 kJ

ii. $2\ H \rightarrow H_2$ ΔE = +436 kJ or (ΔE = -436 kJ)

1e. (2 pts) Under the right conditions, the molecule Na_2 exists. What would you predict about its bond length and strength compared to H_2?

Its bond length would be (larger) or smaller

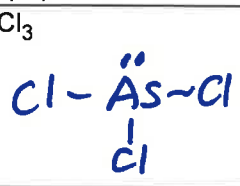
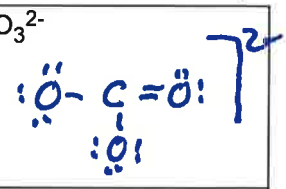
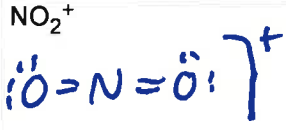
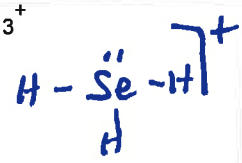
Its bond strength would be larger or (smaller)

1f. (2 pts) Sketch the energy diagram for Na_2 on top of the diagram above so that it can be compared to H_2.

2. (3 pts) Circle the most electronegative element in each set. a. C (O) Ne b. (N) P As c. Ga Ge (As)

3. (3 pts) Circle the most polar bond in each set.
a. C – N or (C – O) b. N – N or (P – O) c. (H – F) or H – Cl

4a. (8 pts) Sketch Lewis dot structures for each of these.

$AsCl_3$ 	CO_3^{2-} 
NO_2^+ 	SeH_3^+ 

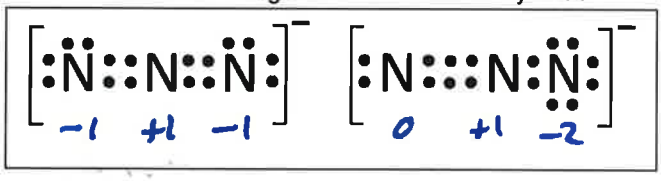
4b. (4 pts) What is the central atom hybridization for each?

$AsCl_3$ sp3	CO_3^{2-} sp2
NO_2^+ sp	SeH_3^+ sp3

4c. (4 pts) What is the shape name for each?

$AsCl_3$ trig pyramid	CO_3^{2-} trig plane
NO_2^+ linear	SeH_3^+ trig pyramid

5a. (6 pts) The azide ion, N_3^-, is used in automobile air bags in the form of sodium azide. Assign formal charges to each atom in these two possible structures. Write the formal charge under each atomic symbol.



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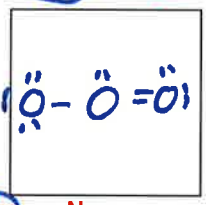


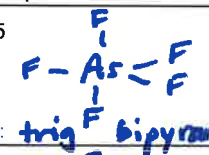
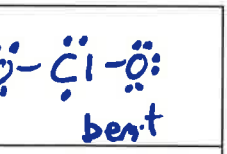
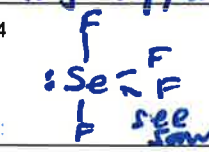
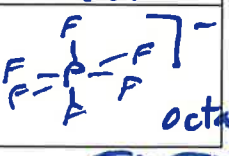
6b. (1 pt) Is ozone polar? **Circle:** (Yes) or No

6c. (1 pt) Does ozone have resonance? **Circle:** (Yes) or No

6b. (2 pt) How many ***total*** σ and π bonds are in ozone?

2 σ and 1 π

7a. (8 pts) Sketch each of these molecules/ions and write the shape name for each.

AsF_5  Shape: trig bipyram	ClO_2  Shape: bent
SeF_4  Shape: see saw	PF_6^-  Shape: octahedral

7b. (3 pts) Which is/are polar? **Circle:** AsF_5 (ClO_2) (SeF_4)

7c. (1 pt) Which one is paramagnetic? ClO_2

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9. The mini-explosion we saw with the soap bubbles is

$$2\ I_2(g) + O_2(g) \rightarrow 2\ H_2O(l) \quad \Delta H^o = -571\ kJ$$

9a. (1 pt) Is this reaction exothermic or endothermic?

9b. (4 pts) The reaction we saw involved about 0.25 mmol $H_2(g)$ with excess $O_2(g)$. How much heat, q, is released/absorbed during this mini-explosion?

Show all work for credit.

Answer with units and correct sign for q: -71 J

9c. (2 pts) What is ΔH for this version of the reaction:

$$H_2O(l) \rightarrow H_2(g) + \tfrac{1}{2}\ O_2(g) \quad \Delta H^o = ?$$

$+285.5$ kJ

9d. (2 pts) Write the chemical equation for the standard heat of formation of $H_2O(l)$ and give its ΔH_f^o value.

$\Delta H_f^o =$ -285.5 kJ/mol H_2O

10. (5 pts) The standard heats of formation for sulfur dioxide and sulfur trioxide are -250 kJ/mol SO_2 and -349 kJ/mol SO_3, respectively. Calculate ΔH^o for this reaction between SO_2 and O_2:

$$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g) \quad \Delta H^o =$$

Show all work for credit.

Answer with units: -198 kJ

11a. (4 pts) Suppose a piece of calcium with mass 1.012 g was added to a coffee cup calorimeter filled with 60.0 g water. The following reaction takes place and is rather vigorous:

$$Ca(s) + 2\ H_2O(g) \rightarrow Ca(OH)_2(aq)$$

The temperature of the calorimeter increased by 55.4 degrees. Calculate q_{cal}. ($c = 4.18\ J\ g^{-1}\ deg^{-1}$)

Show all work for credit.

Answer with units: $+14.1$ kJ

11b. (4 pts) Calculate ΔH for the reaction as given in 11a.

$$Ca(s) + 2\ H_2O(g) \rightarrow Ca(OH)_2(aq) \qquad \Delta H =$$

Answer with units: -160 kJ

12. (3 pts) Which of these reactions is/are exothermic?

a. boiling water: $H_2O(l) \rightarrow H_2O(g)$ ΔH is > 0 or <0

b. combustion of CH_4: ΔH is > 0 or <0

c. soda fizzing: $CO_2(aq) \rightarrow CO_2(g)$ ΔH is > 0 or <0

13. (4 pts) Given the table of bond dissociation energies, estimate ΔH for the reaction:

kJ/mol	H	N	Cl
H	436	390	432
N	390	240	200
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$$NH_3(g) + Cl_2(g) \rightarrow HCl(g) + NH_2Cl(g)$$

$+1$ kJ

14. (10 pts) Nomenclature. Complete the following table. (If you are nomenclature certified, skip this question.)

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	$Cr(NO_3)_3$
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