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.*

Chemistry Student Number: _____

Signature:

Instructions: <mark>Show all work whenever a calculation box is provided!</mark> 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.

1. (8 points) Consider these eight reactions:

A. $HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

B. $2\ C_2H_6(g) + 5\ O_2(g) \rightarrow 4\ CO_2(g) + 6\ H_2O(g)$

C. $Ba(OH)_2 + 2\ HNO_3(aq) \rightarrow 2\ H_2O(l) + Ba(NO_3)_2(aq)$

D. $KCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + KNO_3(aq)$

E. $3\ CuCl_2(aq) + 2\ Al(s) \rightarrow 3\ Cu(s) + 2\ AlCl_3(aq)$

F. $HC_2H_3O_2(aq) + LiOH(aq) \rightarrow H_2O(l) + LiC_2H_3O_2(aq)$

G. $2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$

H. $FeCl_2(aq) + 2\ NaOH(aq) \rightarrow Fe(OH)_2(s) + 2\ NaCl(aq)$

1a. Which of these are acid-base reactions?

A   B   C   D   E   F   G   H

1b. Which of these are oxidation-reduction reactions?

A   B   C   D   E   F   G   H

1a. Which of these are precipitation reactions?

A   B   C   D   E   F   G   H

2. Aqueous barium hydroxide and sulfuric acid react 1:1.

2a. (3 pts) Write the balanced overall reaction that takes place between. Include states of matter: (s), (aq), etc.

2b. (3 pts) Is this an example of: Fill in all that apply: ■

☐ ☐ an acid-base reaction

☐ ☐ a precipitation reaction

☐ ☐ an oxidation-reduction reaction

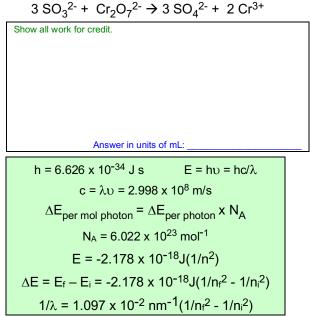3. (6 pts) Assign oxidation states to the semi-metal in each of these ions and compounds.

As_2O_5	$SbCl_2$	Na_2TeO_4
SiO_4^{4-}	Ga_2S_3	GeO_2

4. (4 pts) This is an oxidation-reduction reaction from our previous exam.

$$4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$$

4a. Circle the species oxidized.   **NH₃   O₂   NO   H₂O**

4b. Circle the species reduced.   **NH₃   O₂   NO   H₂O**

4c. Circle the oxidizing agent.   **NH₃   O₂   NO   H₂O**

4d. Circle the reducing agent.   **NH₃   O₂   NO   H₂O**

5. (4 pts) What volume (in mL) of 0.572 M sodium sulfite is needed to react completely with 2.067 g potassium dichromate (MM = 294.185 g mol⁻¹)? (This reaction is only partially balanced, but still provides all the information you need to answer the question.)

$$3\ SO_3^{2-} + Cr_2O_7^{2-} \rightarrow 3\ SO_4^{2-} + 2\ Cr^{3+}$$

Show all work for credit.

Answer in units of mL: _____

$h = 6.626 \times 10^{-34}$ J s $E = h\upsilon = hc/\lambda$

$c = \lambda\upsilon = 2.998 \times 10^8$ m/s

$\Delta E_{per\ mol\ photon} = \Delta E_{per\ photon} \times N_A$

$N_A = 6.022 \times 10^{23}$ mol⁻¹

$E = -2.178 \times 10^{-18}$ J $(1/n^2)$

$\Delta E = E_f - E_i = -2.178 \times 10^{-18}$ J $(1/n_f^2 - 1/n_i^2)$

$1/\lambda = 1.097 \times 10^{-2}$ nm⁻¹ $(1/n_f^2 - 1/n_i^2)$

6a. (4 pts) The characteristic yellow flame that we see when things containing sodium are burned (paper, wood, campfires) is from the emission from sodium's 3p to its 3s orbital and has a wavelength of 588.9950 nm.[1] What is the frequency of this wavelength?
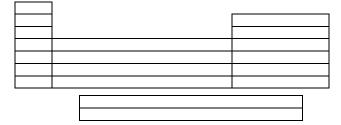
Show all work for credit.

Answer with units: _____

6b. (5 pts) Convert this wavelength (or frequency) to the corresponding energy in kJ/mol.

Show all work for credit.

Answer with units: _____

___

[1] Another smaller yellow emission line is at 589.5924 nm.

7. (5 pts) The relationship between the energy level diagram and the quantum number n is $E \propto 1/n^2$.

7a. For what value of n is the energy the lowest (the most stable energy level)?

n =

7b. Does the energy transition, $n_i = 2 \rightarrow n_f = 1$ absorb energy or emit a photon? ☐ **absorb** or ☐ **emit**

7c. Is the energy for the transition, $n_i = 3 \rightarrow n_f = 2$ associated with a longer or shorter wavelength than for $n_i = 3 \rightarrow n_f = 1$? ☐ **longer** or ☐ **shorter**

7d. Is the energy for the transition, $n_i = 5 \rightarrow n_f = 4$ associated with a more or less energy than the transition $n_i = 4 \rightarrow n_f = 3$? ☐ **more** or ☐ **less**

7e. To remove an electron from hydrogen's ground state, what are n_i and n_f?

n_i =

n_f =

8. (5 pts) Use this periodic table to answer the following.

8a. Write one **X** in each region (box) for which n = 3.

8b. Shade in with your pencil ☐ the elements for which n = 5 and l = 1.

8c. Draw a circle, **O**, in the region of the 4f elements.

8d. Blacken ☐ the box for which n = 6 and l = 2

8e. Draw diagonal lines ▨ through all boxes for which m_l can only equal zero.

9. (6 pts) Give one possible set of quantum numbers for the **last** electron added for each of these atoms? (For example, for lithium, it would be the 3rd electron.)

	n	l	m_l	m_s
Al				
K				
Zn				

10a. (6 pts) Complete the orbital filling diagram (with the arrows up or down) for these ground state atoms.

Fe   [Ar] ___   ___ ___ ___ ___ ___   ___ ___ ___
           4s   3d   4p

Se   [Ar] ___   ___ ___ ___ ___ ___   ___ ___ ___
           4s   3d   4p

10b. (1 pt) How many unpaired electrons are there in a ground state iron atom?

11. (1 pt) What neutral element could have an excited state with configuration $1s^2\ 2s^2\ 3p^1$?

12. (8 pts) Complete this table using ground state electron configurations. Ok to use core notation.

V	
P	
Pd^{2+}	
Se^{2-}	
	Neutral atom, $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
	An ion with a +3 charge, $[Kr]\ 5s^0\ 4d^5$
	Neutral atom, $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$
	An ion with a -1 charge, $[Ne]\ 3s^2\ 3p^6$

13. (6 pts) Circle the species in each pair with the larger radius. Circle 6 choices.

K or **Ca**   **P** or **As**   **Kr** or **Rb**

K or **K^+**   **F** or **F^-**   **Fe^{2+}** or **Fe^{3+}**

14. (3 pts) Circle the species in each pair with larger effective nuclear charge. Circle 3 choices.

Cr or **Mn**   **Ga** or **Ge**   **Li** or **Be**

15. (2 pts) Circle the species in each pair with larger first ionization energy. Circle 2 choices. **Rb** or **Sr**   **Zn** or **Ga**

16. (1 pt) First ionization energies are (**usually** or **always** or **sometimes** or **never**) greater than zero kJ/mol.

17. (1 pt) Second ionization energies are (**usually** or **always** or **sometimes** or **never**) greater than first ionization energies.

18. (2 pts) Circle the orbital in each set with the…

largest third ionization energy **Mg** or **Al** or **P**

largest second ionization energy **K** or **Ca** or **Sc**

19. (3 pts) Circle the species in each pair with the larger electron affinity. Circle 3. **K** or **Ca**   **B** or **C**   **P** or **S**

20. (3 pts) Circle the species in each pair with the larger lattice energy. Circle 3 choices.

KCl or **CaS**   **$CrPO_4$** or **$CaCl_2$**   **K_3PO_4** or **$Ca_3(PO_4)_2$**

21. (10 pts) Nomenclature. Complete the following table. (If you are nomenclature certified, skip this question.)

	$Al_2(SO_4)_3$
	NH_4NO_2
	$CrCl_3$
	B_3N_3
	$KHCO_3$
sulfur tetrafluoride	
cobalt(III) hypochlorite	
copper(I) sulfite	
dinitrogen trioxide	
potassium phosphide	

Answers

1a. **A   C   F**

1b. **B   E   G**

1a. **D   H**

2a. $Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow 2\ H_2O(l) + BaSO_4(s)$

2b. acid-base reaction and precipitation reaction

3. +5,   +2,   +6,   +4,   +3,   +4

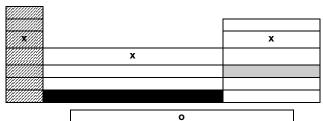4. **NH_3 O_2 O_2 NH_3**

5. 36.9 mL

6a. $5.08 \times 10^{-14}\ s^{-1}$

6b. 203 kJ/mol.

7a. n = 1, 7b. emit, 7c. longer, 7d. less

7e. To remove an electron from hydrogen's ground state, what are $n_i = 1$ and $n_i = \infty$

8.

9.

	n	l	m_l	m_s
Al	3	1	1*	½
K	4	0	0	½
Zn	3	2	-2**	½

* I would accept any of these values: -1, 0, or +1. All are equally correct.

** I would accept any of these values: -2, -1, 0, +1 or +2. All are equally correct.

10a.

10b. 4

11. B

12.

V	[Ar] $4s^2\ 3d^3$
P	[Ar] $3s^2\ 3p^3$
Pd^{2+}	[Kr] $5s^0\ 4d^8$
Se^{2-}	[Ar] $4s^2\ 3d^{10}\ 4p^6$ or [Kr]
Al	Neutral atom, $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
Ru^{3+}	An ion with a +3 charge, [Kr] $5s^0\ 4d^5$
Mn	Neutral atom, $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$
Cl^-	An ion with a -1 charge, [Ne] $3s^2\ 3p^6$

13. **K   As   Rb   K   F⁻   Fe²⁺**

14. **Mn   Ge   Be**

15. **Sr**   (either) **Zn** or **Ga**

16. **always**

17. **always**

18. **Mg**, **K**

19. . **K   C   S**

20. **CaS   CrPO$_4$ Ca$_3$(PO$_4$)$_2$**