

I. Part 1. Laboratory questions 12 pts total)

1. (6 pts) Assume that you have just carried out a reaction between zinc and iodine in lab, adding solid zinc and iodine to acidified water (shaken, in a clean reaction tube). In this experiment, one of the reactants is in excess and one a limiting reagent. The appearance of the reaction mixture will tell you which is which. Describe what the reaction mixture looks like:

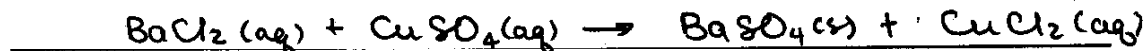
a) Observed, if zinc is the limiting reagent I₂ color

b) Observed, if iodine is the limiting reagent solid metal particles remain (or/and color → clear)

2. (6 pts) You have samples of the following 10 solutions, all 0.10 molar. (These are the compounds that made up the matrix of known solutions in the experiment "Reaction Types and Chemical Logic".)

NH ₃ (aq)	BaCl ₂ (aq)	Cu(NO ₃) ₂ (aq)	CoCl ₂ (aq)	CuSO ₄ (aq)
HCl(aq)	Na ₂ CO ₃ (aq)	NaCl(aq)	NaOH(aq)	H ₂ SO ₄ (aq)

a) (2 pts) Two of these solutions are blue. Mixing one of the blue solutions with one of the colorless solutions gave a white precipitate. The solution remained blue in color. Write a balanced molecular equation for this reaction, including states (s, l, g, aq)

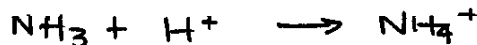


b) (2 pts) From the 8 solutions that remain: select two that when mixed will react with evolution of a gas. What is the formula for the gas that is evolved? (Don't use reagents from parts a)

Gas formation: Reagents Na₂CO₃ and H₂SO₄ Gas formed: CO₂

c) (2 pts) Select an acid and a base from this list and write a net ionic equation for the reaction of these reagents. (Don't use reagents from parts a and b)

Acid-base reaction: acid selected H₂SO₄ or HCl base selected NaOH or NH₃



II. Part 2. Multiple choice (45 pts total) Put answers in the blank space preceding the question.

b 1. The enthalpy of formation of sodium chloride is the heat for which of the following reactions?

- a) $\text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{NaCl}(\text{aq})$
- b) $\text{Na}(\text{s}) + 1/2 \text{Cl}_2(\text{g}) \rightarrow \text{NaCl}(\text{s})$
- c) $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaCl}(\text{s}) + \text{H}_2\text{O}(\text{l})$
- d) $\text{Na}(\text{s}) + \text{Cl}(\text{g}) \rightarrow \text{NaCl}(\text{s})$

a 2. When sulfuric acid dissolves in water, the temperature rises (a lot). What can we conclude about the enthalpy change when sulfuric acid dissolves in water?

- a) This is an exothermic process and $\Delta H_{\text{soln}} < 0$
- b) This is an exothermic process and $\Delta H_{\text{soln}} > 0$
- c) This is an endothermic process and $\Delta H_{\text{soln}} > 0$
- d) This is an endothermic process and $\Delta H_{\text{soln}} < 0$

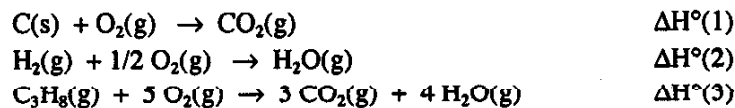
c 3. Which of the following energy quantities are positive values? 1) heat of vaporization of water 2) heat of formation of water 3) ionization of H atoms 4) heat of reaction when hydrogen burns in air 5. electrolysis of water

- a) 1 and 5
- b) 3 and 4
- c) 1, 3, and 5
- d) 2 and 4

b 4. Which of the following is not a state function?

- a) enthalpy
- b) work
- c) temperature
- d) internal energy

d 5. You are given enthalpies for three processes below. Which answer, (a, b, c, or d) will correctly give the standard enthalpy of formation (ΔH°_f) of $\text{C}_3\text{H}_8(\text{g})$?

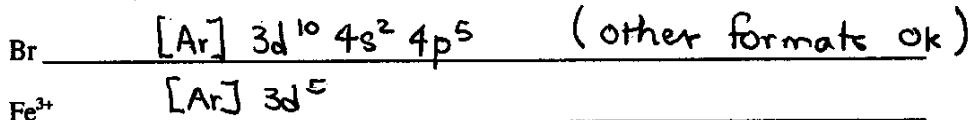


- a) $-3 \Delta H^\circ(1) - 4 \Delta H^\circ(2) + \Delta H^\circ(3)$
- b) $3 \Delta H^\circ(1) + 4 \Delta H^\circ(2) + \Delta H^\circ(3)$
- c) $3 \Delta H^\circ(1) + 2 \Delta H^\circ(2) - \Delta H^\circ(3)$
- d) $3 \Delta H^\circ(1) + 4 \Delta H^\circ(2) - \Delta H^\circ(3)$

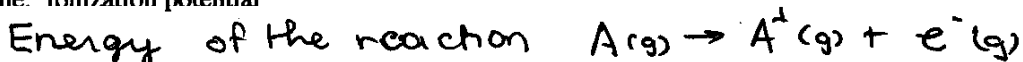
- a 6. Which of the following lines in the atomic spectrum of hydrogen (identified by their wavelength) has the highest energy per photon?
- a) $4.102 \times 10^{-7} \text{ m}$ b) $4.861 \times 10^{-7} \text{ m}$
 c) $4.341 \times 10^{-7} \text{ m}$ d) $6.563 \times 10^{-7} \text{ m}$
- d 7. Which transition in the hydrogen atom among those listed falls in the **visible region** of the spectrum (Bohr theory)?
- a) $n = 7 \rightarrow n = 4$ b) $n = 4 \rightarrow n = 3$ c) $n = 3 \rightarrow n = 1$ d) $n = 5 \rightarrow n = 2$
- c 8. Consider the wave mechanical picture of the potassium atom. Identify the lowest energy orbital that doesn't contain any electrons (assuming it is in the ground state).
- a) 4s b) 4p c) 3d d) 5s
- c 9. In a single atom, how many electrons can be accommodated in the 3rd shell?
- a) 2 b) 8 c) 18 d) 32
- c 10. How many electrons are in a single iron atom (Fe) are unpaired?
- a) 0 b) 2 c) 4 d) 6
- b 11. Which pair of ions, among those listed, are isoelectronic? (isoelectronic = same electron configuration.)
- a) V^{2+} V^{3+} b) V^{2+} Cr^{3+} c) Cr^{2+} Cr^{3+} d) V^{3+} Cr^{2+}
- b 12. Which of the following concerning atom/ion radii is **not** correct?
- a) radius of K > radius of Na c) radius of S > radius of F
 b) radius of Cl > radius of Cl^- d) radius of Na > radius of Na^+
- a 13. Which of the following elements has the highest ionization potential?
- a) Na b) K c) Rb d) Cs
- c 14. Which ion among the following has the largest ionic radius?
- a) O^{2-} b) F^- c) S^{2-} d) Cl^-
- c 15. Which atom in the following list has the largest atomic radius?
- a) F b) O c) S d) Cl

III. Part 3. Short questions and problems. (36 points total)

1. (8 pts) Give the ground state electron configurations for the following



2. (4 pts) Define: Ionization potential



3. (8 pts) The energies of the three lowest orbits in the Bohr description of H are given below.

n = 1 level: -2.18×10^{-18} J/atom

n = 2 level: -5.45×10^{-19} J/atom

n = 3 level: -2.42×10^{-19} J/atom

$\frac{1}{16} \times (-2.18 \times 10^{-18} \text{ J/atom})$

a) What is the energy per photon for the 4th Bohr level?

-1.36×10^{-19} J/atom

b) What is the energy per photon for a transition from n = 2 level to the n = 1 level? (2 → 1)

1.635×10^{-18} J

4. (8 pts) The reaction between 5.00 g Mg and excess oxygen, $2 \text{Mg}(s) + \text{O}_2(g) \rightarrow 2 \text{MgO}(s)$, evolves 123.7 kJ. What is the heat of formation of MgO, (ΔH_f°) in kJ/mol?

$5.00 \text{ g} \left(\frac{1 \text{ mol}}{24.31 \text{ g}} \right) = 0.2057 \text{ mol Mg}$

$\Delta H_f = \frac{-123.7 \text{ J}}{0.2057 \text{ mol}} \left(\frac{1 \text{ kJ}}{10^3 \text{ J}} \right) =$

$\Delta H_f^\circ = \underline{-6.01 \text{ kJ/mol}}$

5. (8 pts) Several standard enthalpies of formation (from Appendix L) are given below.

Species	ΔH_f° (kJ/mol)
Br(g)	111.9
Br ₂ (l)	0
Br ₂ (g)	30.9

Calculate:

a) The heat of vaporization of Br₂; $(\text{Br}_2(l) \rightarrow \text{Br}_2(g))$

$\Delta H = \Delta H^\circ_{\text{prod}} - \Delta H^\circ_{\text{react}}$
 $= 30.9 - 0$
 $= 30.9 \text{ kJ/mol}$

(or 1930 J/g)

$\Delta H^\circ_{\text{vap}} = \underline{30.9 \text{ kJ/mol}}$

b) The energy required for the reaction $\text{Br}_2(g) \rightarrow 2 \text{Br}(g)$. (This is the Br-Br bond energy.)

$\Delta H = \Delta H^\circ_{\text{prod}} - \Delta H^\circ_{\text{react}}$
 $2(111.9) - 30.9$
 $+ 192.9 \text{ kJ}$

$\Delta H^\circ = \underline{192.9 \text{ kJ}}$

Chemistry 105, Lecture 5, and Exam

Part IV. One Problem (8 pts)

1. You have a insulated beaker that contains 22.0 g of ice and 150 g of liquid water, at 0 °C. A 48.2 g block of aluminum is heated to 100.0 °C, and added to this mixture. The SH of Al is 0.897 J/g deg, the SH of H₂O(l) is 4.184 J/g deg, and the heat of fusion of ice is 333 J/g. Here is what we want to determine:

a) First, when thermal equilibrium is reached will all the ice have melted? Show your work on this problem (You won't get credit for a correct answer if work isn't shown. Guesses won't count!)

$$\text{heat needed to melt all ice} = 22.0\text{g} \times 333 \frac{\text{J}}{\text{g}} = 7326 \text{ J}$$

$$\text{heat available when Al cools to } 0^\circ$$

$$= (0.897 \frac{\text{J}}{\text{g} \cdot \text{deg}})(48.2\text{g})(0 - 100) = -4324 \text{ J}$$

insufficient heat to
melt the ice

Did all the ice melt? Yes or No

b) Second: Two choices here: How much ice is left, if only part of the ice melted? Or: If all the ice melted what is the final temperature? WHICH question you answer will be determined by your answer in part a). Fill in your answer in one of the spaces at the bottom. You must show work to get credit for your answer. (x = amt ice melting)

$$q_{\text{ice melting}} + q_{\text{Al cooling to } 0^\circ} = 0$$

$$333x + (-4324) = 0$$

$$x = 12.98 \text{ g } (= 13.0 \text{ g})$$

Ice remaining 22.0 - 13.0 g

If only part of the ice melted, how much ice is left?

9.0 g

If all the ice melted, what is the final temperature of the system?

X