Some Review Problems for Exam 2 – Chem 1A

Note: this selection of problems is **not** comprehensive!

1. a. Would u_{rms} for He $_{(g)}$ at 25°C be less than, greater than, or equal to u_{rms} for $CO_{2\,(g)}$ at 25°C? Why?
   b. True or false: an atom of He at 25°C must always be traveling faster than a molecule of CO_2 at 25°C. Explain.
2. Which of the following orbitals do not exist? Explain, based on allowed values of quantum numbers. 2d, 7s, 5d, 2f
3. Sketch a 4s and a 4d orbital. Show nodes (angular and radial) as dotted lines.
4. Using the activity series in your textbook, predict the outcome of the following:
   a. $Al_{(s)} + H_2SO_{4\,(aq)} \rightarrow$
   b. $Pb_{(s)} + Sn(NO_3)_{2\,(aq)} \rightarrow$
   c. $Sn_{(s)} + Pb(NO_3)_{2\,(aq)} \rightarrow$
5. Which of the following sets of quantum numbers are allowed? Explain.
   a. $n = 4, l = 0, m_l = 2, m_s = + 1/2$
   b. $n = 3, l = 2, m_l = -1, m_s = - 1/2$
6. What is the volume, in liters, occupied by a mixture of 14.8 g Ne and 37.6 g Ar at 14.5 atm and 31.2 °C?
7. A sample of $CO_{2\,(g)}$ travels a distance of 14.8 cm. A sample of an unknown gas travels 17.6 cm in the same amount of time under the same conditions. What is the molar mass of the unknown gas? Explain why your answer is reasonable.
8. Which of the following give(s) a true statement when comparing 0.50 mol H_2 gas and 1.0 mol He gas at STP?
   The two gases have equal (1) average molecular kinetic energies; (2) molecular speeds; (3) volumes; (4) effusion rates.
9. Under which of these conditions is Cl_2 most likely to behave like an ideal gas? Explain. (1) 100°C and 10.0 atm; (2) 0°C and 0.50 atm; (3) 200°C and 0.50 atm; (4) –100°C and 10.0 atm.
10. 40.0 mL of 0.100 M $AlCl_{3\,(aq)}$ and 10.0 mL of 0.300 M Na_2S are mixed. Calculate the ion concentrations in the resulting solution.
11. 35.01 mL of 0.4002 M NaOH is required to react with 25.46 mL of H_2SO_4. Calculate the concentration of the sulfuric acid solution.
12. What volume of 0.3007 M KOH is needed to react with 25.00 mL of 0.2009 M H_3PO_4?
13. 10.89 g of an impure solid containing vitamin C ($H_3C_6H_5O_6$, a triprotic acid) as its only acidic ingredient is titrated with a base. It requires 25.07 mL of 1.531 M KOH to neutralize this sample. What is the mass percent vitamin C in the sample?
14. For the transition of an electron in the hydrogen atom from the n = 1 to the n = 4 energy level:
   a. Is light emitted or absorbed during this transition?
   b. Calculate the wavelength of light emitted or absorbed, in nm.
   c. Calculate the energy in kilojoules per mole of photons.
   d. Give an example of a transition that would correspond to a higher energy photon, and a transition that would correspond to a lower energy photon.

15. A 91.2 mL sample of O_2 is collected over water at 22°C and 738 mmHg barometric pressure. What is the mass of oxygen, in grams, in the collected gas? (The vapor pressure of water at 22°C = 19.8 mmHg.)
16. Rank in order of decreasing radius and explain:
a. Ba^{2+}, I^-, Cs^+ b. S, S^{2-}, O
17. Rank in order of increasing radius and then in order of increasing ionization energy: Te, Br, Sr, C, Cs, F (explain)
18. A gas sample occupies 10.0 L at 1.00 atm. What will happen to the pressure if it is placed in a 20.0-L container? (reason it out without a calculation)
19. Derive Boyle's law, Charles' law, the combined gas law, Avogadro's law, etc. from the ideal gas law.
20. What mass of $CaCl_2$ should be used to make 250.0 mL of a solution that is 0.400 M $Cl^-_{(aq)}$?
21. How much water must be added to 350. mL of 2.00 M HNO_3 to dilute it to 0.500 M?
22. a. The heat of formation of solid Al_2O_3 is –1676 kJ. Write the reaction that corresponds to this ΔH value.
b. The heat of formation of solid $Al(OH)_3$ is –1276 kJ. Write the reaction that corresponds to this ΔH value.
c. The heat of formation of liquid H_2O is –285.8 kJ. Write the reaction that corresponds to this ΔH value.
d. Use the above reactions and their ΔH values to determine the ΔH for the following reaction:
$$Al_2O_{3\,(s)} + 3\ H_2O_{(l)} \rightarrow 2\ Al(OH)_{3\,(s)}$$
23. a. Calculate work (at 25°C) for the following reaction:
$CH_{4\,(g)} + NH_{3\,(g)} \rightarrow HCN_{(g)} + 3\ H_{2\,(g)}$ $\Delta H = +256$ kJ
b. Calculate ΔE for the above reaction.
c. If 1 mole of methane and 1 mole of ammonia were reacted in a bomb calorimeter, how much heat would be given off or absorbed? (Specify which.) Would the temperature of the calorimeter and its contents increase or decrease?
24. 35.0 g of steam, originally at 121.3 °C, is added to some water in a coffee-cup calorimeter which is originally at 19.7 °C. When the mixture comes to thermal equilibrium, the temperature of all of the water in the cup is 47.1 °C. What mass of water must have been in the cup? State any assumptions made. Draw a phase diagram if you wish.
25. Given the thermochemical equation:
$CaO_{(s)} + 3\ C_{(s)} \rightarrow CaC_{2\,(s)} + CO_{(g)}$ $\Delta H = +464.8$ kJ
a. Is this reaction exothermic or endothermic?
b. Is heat released or absorbed in the above reaction?
c. If you start with 50.0 g of carbon and excess calcium oxide, how much heat will be evolved or absorbed? (Specify the sign and whether it is evolved or absorbed.)
26. 5.00 g of sulfur (S_8) is burned in a bomb calorimeter with excess oxygen gas. The temperature increases from 21.43 °C to 22.77 °C. The entire bomb calorimeter, including the water, has a heat capacity of 4.333 kJ/°C. Write the equation for this reaction, and determine ΔE and ΔH for the reaction as written.
27. The specific heat capacity of aluminum is higher than the specific heat capacity of iron. If you held a room-temperature piece of aluminum in one hand and a room-

temperature piece of iron in the other hand (assume they have equal masses), which one would reach body temperature first? Explain.

28. a. For the reaction:

$Mg_{(s)} + 2\ HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$

Calculate ΔH_{rxn} from ΔH°_f values.

ΔH°_f values at 25°C:

$Mg_{(s)}$	0 kJ
$Mg^{2+}_{(aq)}$	- 461.96 kJ
$H^+_{(aq)}$	0 kJ
$H_{2\,(g)}$	0 kJ
$Cl^-_{(aq)}$	- 167.2 kJ

b. If you use 0.200 g Mg and 100. mL of 1.0 M HCl in a Styrofoam cup calorimeter in which the initial temperature is 20. °C, what will the final temperature be? Make any reasonable approximations needed (and state those approximations).

29. Benzoic acid, $C_7H_6O_2$, occurs naturally in many berries. Suppose you burn 1.500 g of the compound in a combustion calorimeter and find that the temperature of the calorimeter increases from 22.50 °C to 31.69 °C. The calorimeter contains 775 g of water, and the bomb has a heat capacity of 893 J/K. How much heat is evolved per mole of benzoic acid?

30. Refer to the problem above. The balanced equation for the combustion of benzoic acid is

$2\ C_7H_6O_{2\,(s)} + 15\ O_{2\,(g)} \rightarrow 14\ CO_{2\,(g)} + 6\ H_2O_{(l).}$

Calculate ΔE and ΔH for the above reaction as written. Assume the reaction occurs at 31.69°C.

31. Determine what element is oxidized and what element is reduced in the following reaction: $S_2O_3^{2-} + 5\ I_2 + 5\ H_2O \rightarrow 10\ I^- + S_2O_8^{2-} + 10\ H^+$

32. 2.00 g of CaO is mixed with 200. mL of 1.50 M HBr in a coffee-cup calorimeter. The temperature of the solution increases from 19.2 °C to 27.5 °C. Calculate ΔH for the following reaction as written, in kJ. Make any reasonable and necessary assumptions, and **state those assumptions**.

$CaO_{(s)} + 2\ HBr_{(aq)} \rightarrow CaBr_{2\,(aq)} + H_2O_{(l)}$ $\Delta H = ?$

33. Write electron configurations for:

a. N (arrow diagram)

b. Br (full e^- configuration)

c. Cr (noble gas notation and arrow diagram for outermost s and d electrons)

d. Rh (noble gas notation and arrow diagram for outermost s and d electrons)

e. Ca^{2+}

f. Ni^{2+}(noble gas notation)

g. O^{2-}

34. Calculate the density of $SO_{2\,(g)}$ at 25°C and 820 mm Hg.

35. An unknown gas has a density of 1.06 g/L at 35°C and 0.988 atm. Calculate the molar mass of this gas.

36. If 2.00 g of aluminum carbonate reacts with 100. mL of 0.100 M nitric acid and the carbon dioxide is collected over water, what volume of CO_2 would be produced at 25°C when the atmospheric pressure is 753.2 torr?

$$Al_2(CO_3)_{3\,(s)} + HNO_{3\,(aq)} \rightarrow H_2O_{(l)} + CO_{2\,(g)} + Al(NO_3)_{3\,(aq)}$$

Some Answers:

1. a. greater than
   b. false. at any T, there is a distribution of speeds.
2. 2d, 2f
3. See lecture notes
4. a. $2Al + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\ H_2$
   b. NR
   c. $Sn + Pb(NO_3)_2 \rightarrow Pb + Sn(NO_3)_2$
5. a. not allowed
   b. allowed
6. 2.88 L
7. 31.1 g/mol
8. 1
9. 3
10. $[S^{2-}] = 0$ M, $[Al^{3=}] = 0.0400$ M, $[Na^+] = 0.120$ M, $[Cl^-] = 0.240$ M
11. 0.2752 M H_2SO_4
12. 501.1 mL
13. 20.69 % vit. C
14. absorbed, 97.2 nm, 1230 kJ/mol, higher E photon: 1 to 5, lower E: 1 to2
15. 0.114 g
16. a. I^-, Cs^+, Ba^{2+}
    b. S^{2-}, S, O
17. a. F, C, Br, Te, Sr, Cs
17. b. opposite order
18. P will halve, because V doubled. P = 0.500 atm.
19. See lecture notes.
20. 5.55 g $CaCl_2$
21. 1.05 L water
22. $\Delta H = -19$ kJ
23. a. – 4.96 kJ
    b. + 251 kJ
    c. T decrease
24. 771 g water
25. a. endo
    b. absorbed
    c. ± 64.5 kJ (absorbed)
26. If product is SO_2:
    $\Delta E = -298$ kJ, $\Delta H = -298$ kJ
    If product is SO_3:
    $\Delta E = -298$ kJ, $\Delta H = -308$ kJ
27. Fe
28. a. $\Delta H = -461.96$ kJ
    b. 29°C
29, 30 See extra thermo problems handout
31. S is oxidized, I is reduced.
32. $\Delta H = -2.0 \times 10^2$ kJ
34. 2.83 g/L
35. 27.1 g/mol
36. 127 mL