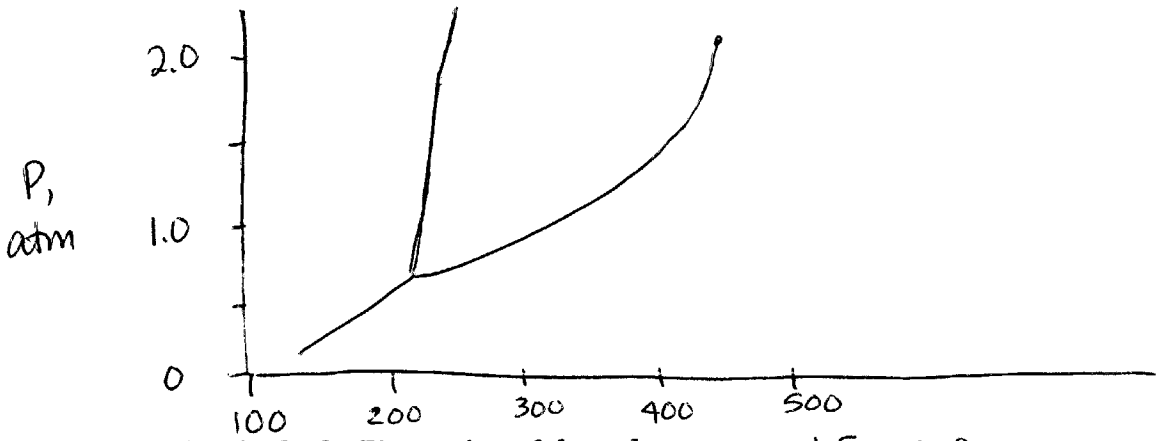
Some Review Problems for Exam 3 – Chem 1A

(Note – this selection of problems is **not** comprehensive!)

1. How many grams of ethylene glycol ($C_2H_4(OH)_2$) must be added to 400. g of water to bring the freezing point of the solution down to -15°C?
2. A solution is made by dissolving 50.0 g urea, $CO(NH_2)_2$, in 275 g of water.
   a. Calculate the vapor pressure of this solution at 45°C.
   b. Calculate the boiling point of the solution.
   c. Calculate the freezing point of the solution.
   Look up any necessary information from your textbook.
3. Classify each of the following by the type of solid it would form.
   a. SiC
   b. Pb
4. Explain why quartz (SiO_2, mp = 1610°C) has a <u>much</u> higher melting point than CO_2 (mp = -78.5°C).
5. A solution contains 3.75 g of a nonvolatile pure hydrocarbon in 95 g of acetone. The boiling points of pure acetone and the solution are 55.95°C and 56.50°C, respectively. The boiling-point constant of acetone is 1.71 °C/m. What is the molar mass of the hydrocarbon?
6. The normal boiling point of methanol is 64.7°C. A solution containing a nonvolatile solute dissolved in methanol has a vapor pressure of 710.0 mmHg at 64.7°C. what is the mole fraction of methanol in this solution?
7. Given the following substances:
   A. $C_8H_{17}OH$ B. CaS C. KCl
   Rank in order of decreasing melting point (highest to lowest) and briefly explain your reasoning.
8. For the ions F_2^- and F_2^{2+}:
   a. Which would be the easiest to dissociate?
   b. Which would have the shortest F-F bond?
   Explain, including the molecular orbital electron configuration of each species in your explanation.
9. When isopropyl alcohol evaporates from your skin, your skin cools off. Explain why.
10. Which would you expect to have a higher heat of vaporization, $C_6H_{13}OH$ or C_2H_5OH ? Explain.
11. Which would be more soluble in octane, C_8H_{18}:
    a. 1-heptanol, $C_7H_{15}OH$
    b. ethanol, C_2H_5OH
    Explain.
12. The normal boiling point of benzene, C_6H_6, is 80.1 °C, while the normal boiling point of water is 100 °C. Explain why water has a higher boiling point, even though it has a much lower molar mass than benzene.
13. Given the following molecules:
    A. CH_3CHFCH_3 B. $CH_3CH_2CH_2NH_2$ C. $C_{10}H_{22}$

a. Rank them in order of increasing boiling point (lowest to highest) and explain your reasoning.
b. Which would you expect to have the highest vapor pressure? Explain.
c. Rank them in order from the most to least soluble in water and explain your reasoning.

14. Given the following phase diagram:



a. What is the boiling point of the substance at 1.5 atm?
b. Will this substance melt at a pressure of 0.9 atm? At 0.5 atm?
c. What phase will the substance be in at 1.0 atm and 150 K?
d. What is the normal boiling point of this substance?
e. If the substance is at 0.25 atm and 400 K, what could you do to liquefy it?
f. What is the vapor pressure of substance A at 250 K?

15. A solution has a mass percent glucose ($C_6H_{12}O_6$) in water of 35.4 %. What is the molality of this solution? What is the boiling point of this solution?

16. a. Calculate the solubility of O_2 in water at a partial pressure of O_2 of 120. torr at 25°C. The Henry's law constant for O_2 is 3.5×10^{-4} M/atm.
b. Will the solubility be higher, lower, or the same at 50°C?

17. Which would have the highest vapor pressure:
a. pure water at 25°C
b. 1 M $NaCl_{(aq)}$ at 25°C
c. pure water at 50°C
d. 1 M $NaCl_{(aq)}$ at 50°C
Explain.

18. The osmolarity of a solution is the concentration (in molarity) of solute particles in the solution. The osmolarity of blood is 0.308 M. If a solution of 0.115 M $CaCl_{2\,(aq)}$ was injected into the bloodstream, what would happen, if anything, to the red blood cells in the vicinity of the injection? Explain in detail. Assume the cell membrane is only permeable to water. Draw a diagram if you want.

19. Solution A contains 0.10 M sucrose. Solution B contains 0.070 M sodium chloride. Will solution B have a higher, lower, or equal osmotic pressure compared to solution A? Explain in one sentence.

20. An aqueous solution is 0.273 m KCl. What is the molarity of KCl in this solution? The density of the solution is 1.011 g/mL.

21. An aqueous solution is 0.907 M $Pb(NO_3)_2$. What is the molality of lead (II) nitrate in this solution? The density of the solution is 1.252 g/mL.
22. Draw the Lewis structure, state the shape, bond angles, hybridization, and polarity of the following molecules or ions:
ICl_4^+, ICl_4^-, N_2H_2, H_2Se, CS_2, $COCl_2$, SbF_4^-, ClO_4^-, PO_4^{3-}, HIO_2
23. Describe the bonding in the following using valence-bond theory:
ICl_4^+, ICl_4^-, N_2H_2
24. Draw the Lewis structure for each of the following organic molecules.
a. $CH_3OCH_2CH_3$
b. CH_3CH_2F
c. CH_3NHCH_3
d. CH_2CHCH_3
e. CH_3COOH
f. $CH_3COOCH_2CH_3$
25. Why are metallic solids malleable, while ionic solids are brittle?
26. If the humidity is 53% at 60°F, what is the partial pressure of water vapor in the air? What is the dew point?
27. If the partial pressure of water vapor in the air is 12.1 torr at 22°C, what is the percent relative humidity?
28. Use bond dissociation energies to estimate ΔH for the following reaction.
$2\ C_2H_{6\,(g)} + 7\ O_{2\,(g)} \rightarrow 4\ CO_{2\,(g)} + 6\ H_2O_{(g)}$
Why is it an estimate? Is this reaction exothermic or endothermic? What is more stable, reactants or products?
29. The concentration of $NaNO_3$ in an aqueous solution is 2.04 m. Calculate the mass percent and the mole fraction of $NaNO_3$ in this solution. Calculate the vapor pressure of this solution at 45°C.
30. An aqueous solution contains 0.18 ppm Li^+. What mass of lithium ion is in 300. mL of this solution?
31. If an aqueous solution contains 5.2 mg of Ag^+ in 3.0 L of solution. Calculate the concentration in ppm.
32. Rank in order of decreasing radius and explain:
a. Mg^{2+}, F^-, Na^+ b. S, S^{2-}, O
33. Rank in order of increasing radius and then in order of increasing ionization energy: Te, Br, Sr, C, Cs, F (explain)
34. Write electron configurations for:
a. N (arrow diagram)
b. Br (full e^- configuration)
c. Cu (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-}
35. The ionization energy of N is 1402 kJ/mol, while the ionization energy of O is 1314 kJ/mol. Explain.
36. The first ionization energy of Na is 495 kJ/mol, while the second IE of Na is 4562 kJ/mol. Explain.
37. Which atom is easiest to add an electron to, P, Cl, or Al?

38. State one or two important properties of:
a. metals
b. nonmetals
c. metalloids
d. alkali metals
e. alkaline earth metals
f. halogens
g. noble gases
h. hydrogen
i. sulfur
j. oxygen

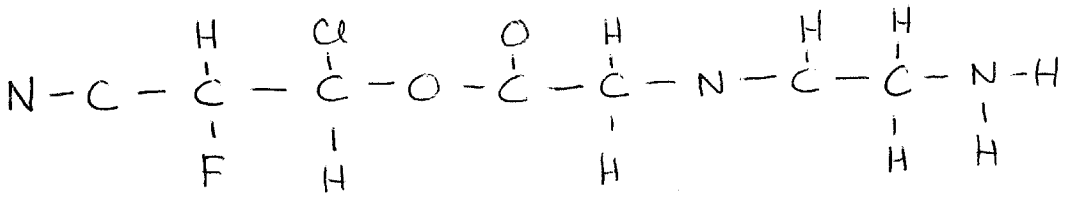
39. a. Which has the higher lattice energy, $MgCl_2$ or $MgBr_2$? Explain.
b. Which has the higher melting point, SrI or CaS?

40. Which of the following orbitals do not exist? Explain, based on allowed values of quantum numbers. 2d, 7s, 5d, 2f

41. Sketch a 4s and a 4d orbital. Show nodes (angular and radial) as dotted lines.

42. Which of the following sets of quantum numbers are allowed? Explain.
a. $n = 4, l = 0, m_l = 2, m_s = + 1/2$
b. $n = 3, l = 2, m_l = -1, m_s = - ½$

43. Fill in any multiple bonds and lone pairs in the following structure. State the shape, bond angle, and hybridization around each central atom.



Some Answers:

1. 2.0×10^2 g
2a. 68.2 mm Hg
2b. 101.5 °C
2c. - 5.63 °C
3a. network
3b. metallic
4. network vs. molecular
5. 120 g/mol
6. 0.9342
7. B, C, A
8. F_2^-, F_2^{2+}
9. evap requires energy
10. $C_6H_{13}OH$
11. 1-heptanol
12. water can H-bond
13a. A, B, C
13b. A
13c. C, A, B
14a. ~410 K
14b. yes, no
14c. solid
14d. ~340 K
14e. increase P
14f. ~0.7 atm
15. 101.6 °C
16a. 5.5×10^{-5} M
16b. lower
17. c
18. cells shrink
19. B
20. 0.270 M
21. 0.953 m
26. ~6.9 torr, 43°F
27. 61.0% humidity
28. -2831 kJ, exo, products
29. 14.8%, 0.0354, 69.3 torr
30. 5.4×10^{-5} g Li^+
31. 1.7 ppm
40. 2d, 2f
42. a is not allowed, b is allowed