

Exam 3

Review Answers

1

$$1. \Delta T_f = K_f m \quad K_f = 1.86^\circ\text{C}/m$$

$$m = \frac{\Delta T_f}{K_f} = \frac{15^\circ\text{C}}{1.86^\circ\text{C}/m} = 8.0645 \text{ mol} = \frac{8.0645 \text{ mol EtG}}{1 \text{ kg H}_2\text{O}}$$

$$(0.400 \text{ kg H}_2\text{O}) \left(\frac{8.0645 \text{ mol EtG}}{1 \text{ kg H}_2\text{O}} \right) \left(\frac{62.068 \text{ g}}{1 \text{ mol}} \right) = 200.2 \text{ g Ethylene glycol}$$

$$2a. \text{ At } 45^\circ\text{C, } v_p \text{ H}_2\text{O} = 71.9 \text{ torr} \quad (50.0 \text{ g urea}) \left(\frac{1 \text{ mol}}{60.062 \text{ g}} \right) = 0.83247 \text{ mol urea}$$

$$P_A = X_A P_A^\circ$$

$$(275 \text{ g H}_2\text{O}) \left(\frac{1 \text{ mol}}{18.016 \text{ g}} \right) = 15.264 \text{ mol H}_2\text{O}$$

$$X_{H_2\text{O}} = \frac{15.264 \text{ mol H}_2\text{O}}{(0.83247 + 15.264) \text{ mol}} = 0.9483$$

$$P_A = (0.9483)(71.9 \text{ torr}) = 68.2 \text{ mm Hg}$$

$$b. \Delta T_b = K_b m \quad K_b \text{ H}_2\text{O} = 0.51^\circ\text{C}/m \quad \frac{0.83247 \text{ mol urea}}{0.275 \text{ kg H}_2\text{O}} = 3.027 \text{ m}$$

$$\Delta T_b = (0.51^\circ\text{C}/m)(3.027 \text{ m}) = 1.54^\circ\text{C}$$

$$bp = \frac{100}{(\text{exact})} + 1.5^\circ\text{C} \Rightarrow 101.5^\circ\text{C}$$

$$c. \Delta T_f = K_f m \quad K_f \text{ H}_2\text{O} = 1.86^\circ\text{C}/m$$

$$\Delta T_f = (1.86^\circ\text{C}/m)(3.027 \text{ m}) = 5.630^\circ\text{C}$$

$$T_f = 0 - 5.630^\circ\text{C} = -5.63^\circ\text{C}$$

3. a) network b) metallic

4. quartz: network (must break covalent bonds)

CO_2 : molecular (must disrupt London dispersion forces, which are much weaker than covalent bonds.)

5. 3.75 g unk. 95 g acetone

bp acetone 56.95°C solution 56.50°C $\Delta T_b = 0.55^\circ\text{C}$

$$\Delta T_b = K_b m$$

$$m = \frac{\Delta T_b}{K_b} = \frac{0.55^\circ\text{C}}{1.71^\circ\text{C}/m} = 0.3216 \text{ mol} = \frac{0.3216 \text{ mol unk}}{1 \text{ kg acetone}}$$

$$(0.095 \text{ kg acetone}) \left(\frac{0.3216 \text{ mol unk}}{1 \text{ kg acetone}} \right) = 0.030556 \text{ mol unk}$$

$$\frac{3.75 \text{ g unk}}{0.030556 \text{ mol unk}} = 122.7 \text{ g/mol}$$

(120 g/mol) (2sf)

(2)

6. n bp methanol = 64.7°C at the bp, vp = 760 mmHg (exact)

vp = 710.0 mmHg at 64.7°C $X_{\text{methanol}} = ?$

$$P_A = X_A P_A^{\circ} \quad X_A = \frac{P_A}{P_A^{\circ}} = \frac{710.0 \text{ mmHg}}{760 \text{ mmHg}} = 0.9342$$

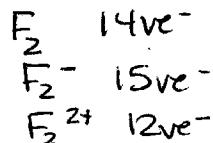
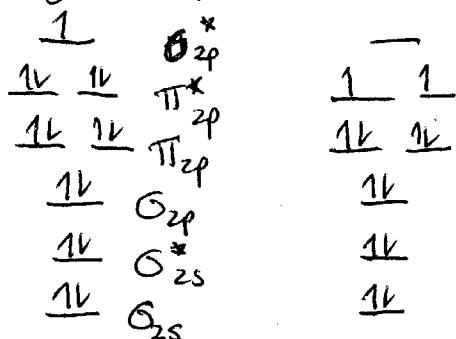
7. A is molecular. B and C are ionic. Ionic substances have much higher mps. (Ionic bonds are much stronger than IMF's)



higher charges, stronger attractions.

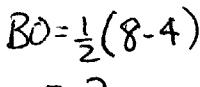
Highest mp: (B), (C), (A)

8.



$$\text{BO} = \frac{1}{2}(8-7) = 0.5$$

easiest to dissociate



shortest bond.

9. Energy is required for evaporation - heat is transferred from your skin, so skin cools.

10. Both can H-bond, but $\text{C}_6\text{H}_{13}\text{OH}$ has a significantly higher molar mass and much stronger London forces.

Stronger attractive forces \Rightarrow harder to separate \Rightarrow higher ΔH_{vap}

11. 1-heptanol would be more soluble in C_8H_{18} .

C_8H_{18} is nonpolar. 1-heptanol has a long nonpolar section.

(3)

12. Benzene is nonpolar and has only London dispersion forces. H₂O is polar and can H-bond to each other.
 MM = 78.108 g/mol MM = 18.016 g/mol

Benzene's dispersion forces are stronger than H₂O's. However, the H-bonds in water are ~~stronger than~~ so strong that it's enough to outweigh the strong dispersion forces in benzene. (The one with the higher bp has stronger IMF's overall.)

13. A. Polar but can't H-bond MM = 62 g/mol $\text{H}-\overset{\text{#}}{\underset{\text{H}}{\text{C}}}-\overset{\text{F}}{\underset{\text{H}}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\text{H}$
 B. Polar and can H-bond MM = 59 g/mol
 C. Nonpolar but much higher MM Similar MM
 than A and B. MM = 142 g/mol Strongest IMF's overall

- a. lowest bp A, B, C highest bp
 b. highest vp - most evaporation - the one w/the lowest bp. - (A)

- C. least soluble in H₂O (C) nonpolar (A) polar (B) polar, can H-bond most soluble

14. a. ~ 410 K d. ~ 340 K
 b. yes, no e. increase pressure
 c. solid f. ~ 0.7 atm

15. $\frac{35.4 \text{ g gluc}}{100 \text{ g solution}}$ $35.4 \text{ g gluc} / (100 - 35.4) = 64.6 \text{ g H}_2\text{O}$
 $(35.4 \text{ g gluc}) / \left(\frac{1 \text{ mol}}{180.156 \text{ g}} \right) = 0.1965 \text{ mol gluc}$

$$m = \frac{0.1965 \text{ mol gluc}}{0.0646 \text{ kg H}_2\text{O}} = 3.0418 \text{ m}$$

$$\Delta T_b = K_b m = (0.51^\circ\text{C/m})(3.0418 \text{ m}) = 1.5513^\circ\text{C}$$

$$T_b = \cancel{100^\circ\text{C}} + 1.5513^\circ\text{C} = \boxed{101.6^\circ\text{C}}$$

16. $S_g = K P_g$ $K = \frac{3.5 \times 10^4 \text{ atm}}{\cancel{atm}} M$ $(120. \text{ torr}) / \left(\frac{1 \text{ atm}}{760 \text{ torr}} \right) = 0.1579 \text{ atm}$

$$S_g = (0.1579 \text{ atm}) / \left(\frac{3.5 \times 10^4 \text{ atm}}{\cancel{\text{atm}}} M \right) = \boxed{5.5 \times 10^{-5} \text{ M}}$$

(b) Lower at a higher temp. (it's a gas.)

(4)

17. higher T, higher νp (more molecules have enough E to escape)
more concentrated solution, lower νp .

Highest νp : pure solvent @ high T. (c)

18. CaCl_2 splits into 3 ions (less)

$$0.115 \text{ M} \times 3 = 0.345 \text{ osM}$$

0.308
0.5 M

<0.345 osM

H_2O will flow out to dilute the more concentrated solution.
cells will shrink.

19. A

$$0.10 \text{ M sucrose} = 0.10 \text{ osM}$$

B splits into 2 ions.

$$0.070 \text{ M NaCl} \Rightarrow < 0.14 \text{ osM}$$

B will have a higher osmotic pressure. It has a higher conc. of solute particles.

20.

$$0.273 \text{ m KCl} \Rightarrow \frac{0.273 \text{ mol KCl}}{1 \text{ kg H}_2\text{O}}$$

want $\frac{\# \text{ mol KCl}}{1 \text{ L solution}}$

1.011 g solution
1 mL solution

what V solution contains
1 kg H_2O ?

$$(0.273 \text{ mol KCl}) \left(\frac{74.55 \text{ g KCl}}{1 \text{ mol KCl}} \right) = 20.352 \text{ g KCl}$$

$$\text{In } 1 \text{ kg H}_2\text{O, } 20.352 \text{ g KCl mass solution} = 1020.352 \text{ g}$$

$$(1020.352 \text{ g solution}) / \left(\frac{1 \text{ mL solution}}{1.011 \text{ g solution}} \right) = 1009.25 \text{ mL solution}$$

$$\frac{0.273 \text{ mol KCl}}{1009.25 \text{ L soln}} = 0.270498 \text{ M} = \textcircled{0.270 \text{ M}}$$

$$21. 0.907 \text{ M Pb(NO}_3)_2 = \frac{0.907 \text{ mol Pb(NO}_3)_2}{1 \text{ L solution}} \text{ want } \frac{\# \text{ mol Pb(NO}_3)_2}{1 \text{ kg H}_2\text{O}}$$

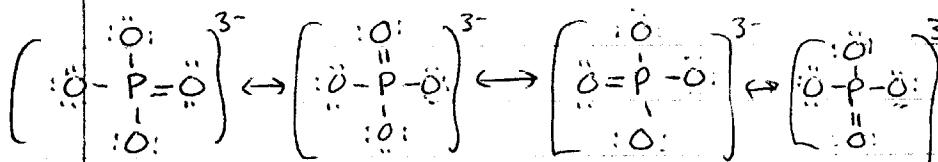
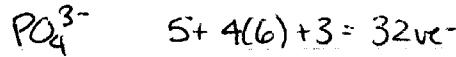
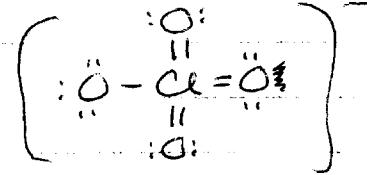
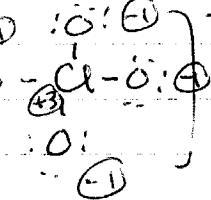
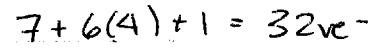
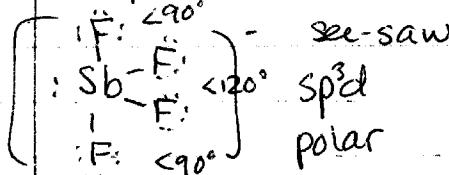
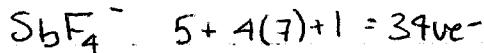
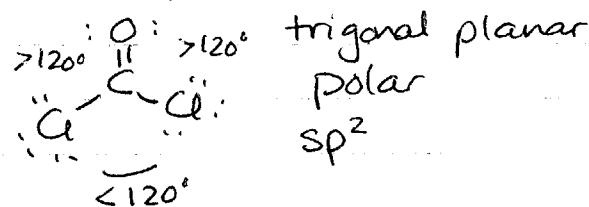
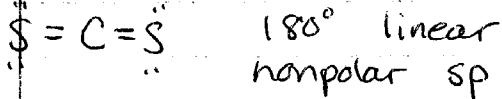
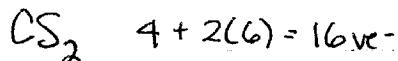
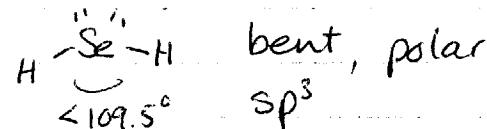
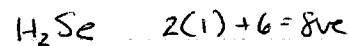
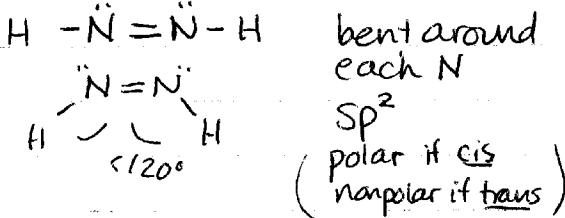
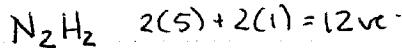
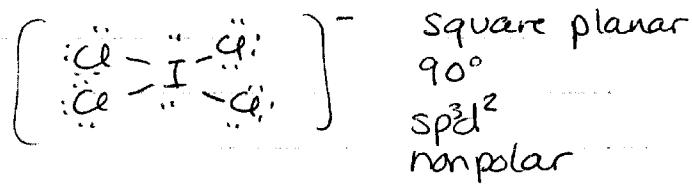
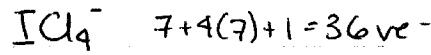
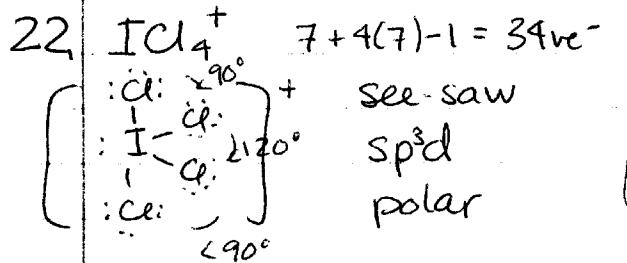
$d_{\text{sd}} = \frac{1.252 \text{ g solution}}{1 \text{ mL solution.}}$

$$(0.907 \text{ mol Pb(NO}_3)_2) \left(\frac{331.22 \text{ g}}{1 \text{ mol}} \right) = 300.4 \text{ g solute}$$

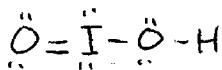
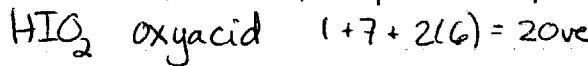
$$(1000 \text{ mL soln}) \left(\frac{1.252 \text{ g soln}}{1 \text{ mL soln}} \right) = \frac{1252 \text{ g solution}}{-300.4 \text{ g solute}} = \frac{951.6 \text{ g H}_2\text{O}}{951.6 \text{ g H}_2\text{O}}$$

$$\frac{0.907 \text{ mol}}{0.9516 \text{ kg H}_2\text{O}} = \textcircled{0.953 \text{ m}}$$

(5)

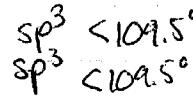


tetrahedral, 109.5° , nonpolar, sp^3

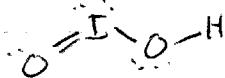


FC is minimized
 all atoms have O
 FC

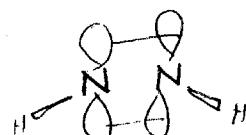
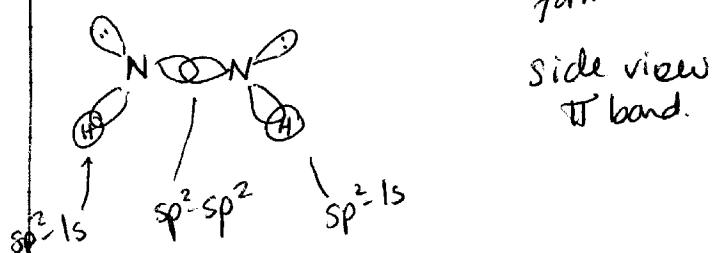
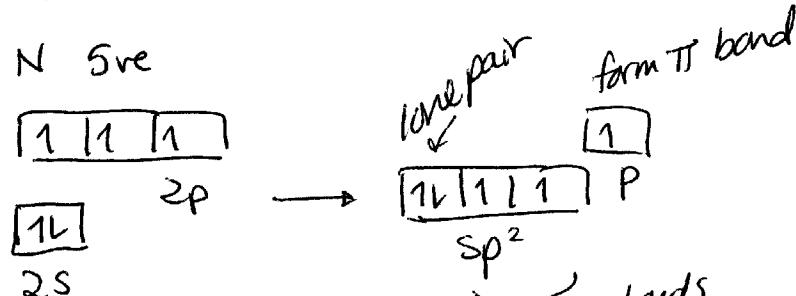
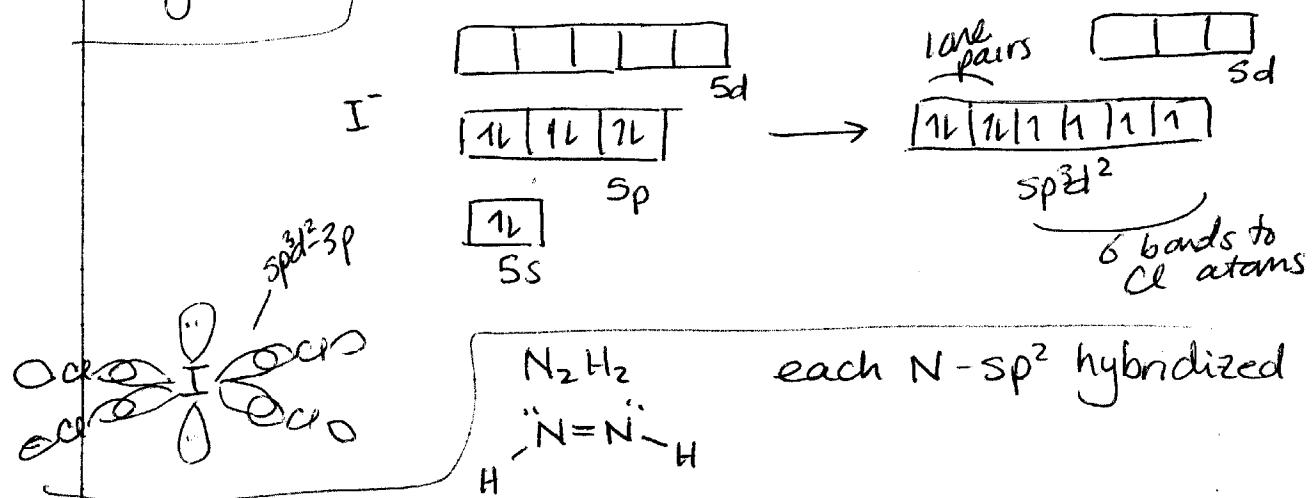
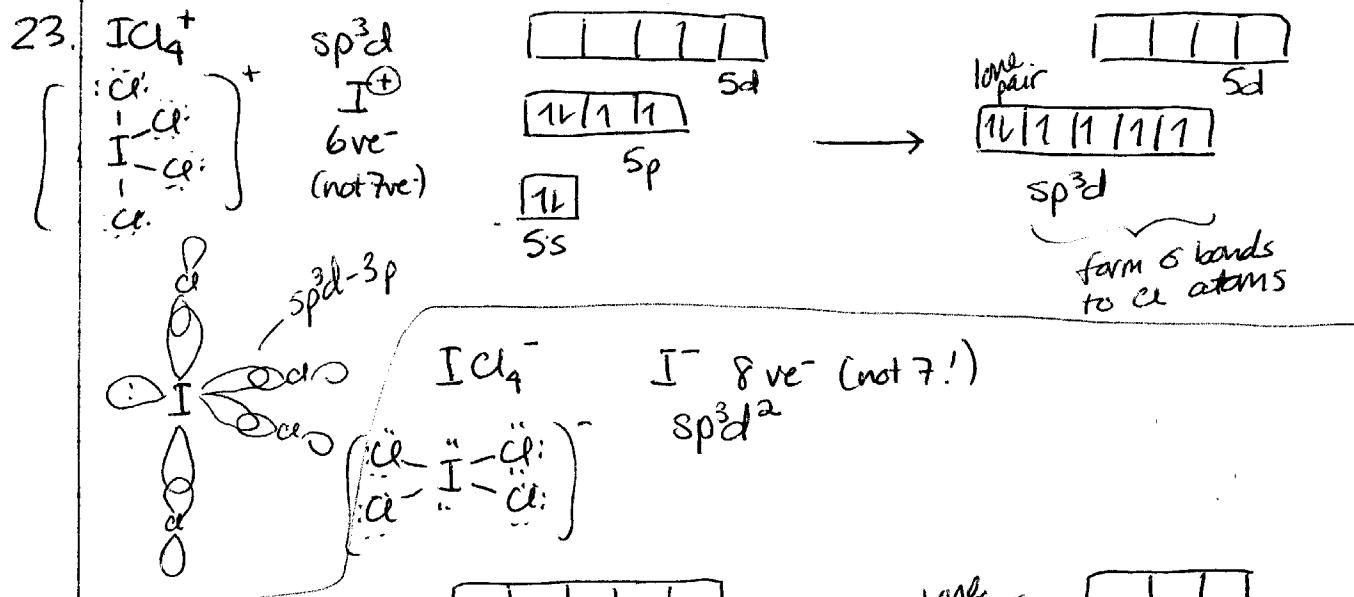
bent around I
 bent around O
 polar



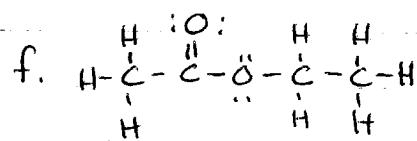
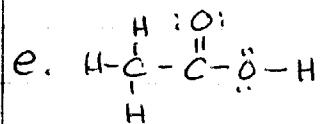
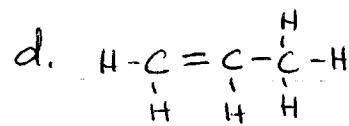
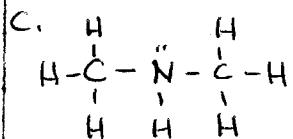
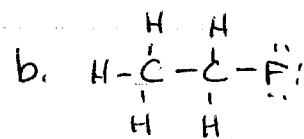
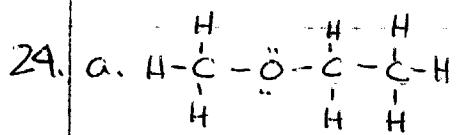
tetrahedral, sp^3
 nonpolar, 109.5°



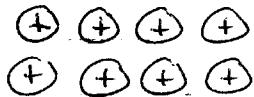
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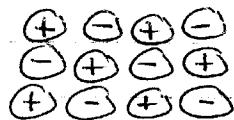
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25. Metallic solids



Ionic solids

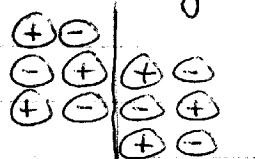


⊕ ionic cores held together by a sea of e-. If ionic cores shift positions, it won't affect bonding.

alternating ⊕ and ⊖ charges. if positions shift, it will disrupt ionic bonds.
(like charges repel)

26. $60^{\circ}\text{F} \quad {}^{\circ}\text{C} = \frac{({}^{\circ}\text{F}-32)}{1.8}$

${}^{\circ}\text{C} = \frac{(60-32)}{1.8} = 15.55 {}^{\circ}\text{C}$



will break

vp of water @ $15^{\circ}\text{C} = 12.79 \text{ torr}$
 $16^{\circ}\text{C} = 13.63 \text{ torr}$) somewhere in between.
 let's round to 13 torr.

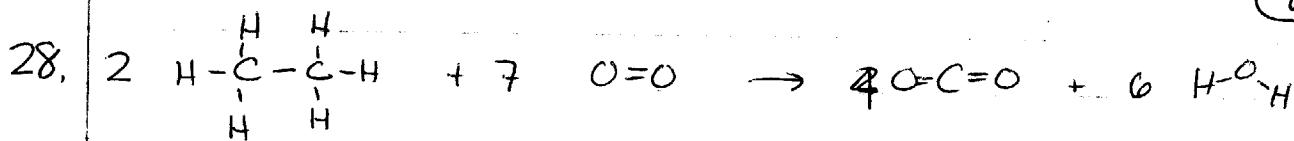
53% of 13 torr is: $13 \text{ torr} \times 0.53 = 6.89 \text{ torr}$ so $\sim 6.9 \text{ torr} =$
 dew point ... T at which $vp = 6.9 \text{ torr}$ partial P of $\text{H}_2\text{O}_{(g)}$

approx 6°C or ${}^{\circ}\text{F} = ({}^{\circ}\text{C})(1.8) + 32 = 6(1.8) + 32 = 43^{\circ}\text{F}$

27. At 22°C , eq. $vp = 19.83 \text{ torr}$ (max)

$\frac{12.1 \text{ torr}}{19.83 \text{ torr}} \times 100 = 61.0\%$ humidity

(8)

break (ΔH°_f)

$$\begin{array}{lcl} 2 \text{ C-C bonds} & + 2(348 \text{ kJ}) & = + 696 \text{ kJ} \\ 12 \text{ C-H bonds} & + 12(413 \text{ kJ}) & = + 4956 \\ 7 \text{ O=O bonds} & + 7(495 \text{ kJ}) & = + 3465 \end{array}$$

form ΔH°_f

$$\begin{array}{lcl} 8 \text{ C=O bonds} & - 8(799 \text{ kJ}) & = - 6392 \\ 12 \text{ O-H bonds} & - 12(463 \text{ kJ}) & = - 5556 \end{array}$$

exothermic

products more stable

$$\Delta H_{rxn} = -2831 \text{ kJ}$$

We used average bond dissociation energies in the calculations. Bond strengths are slightly different in different molecules or in different positions within a molecule.

29. 2.04 m NaNO_3 $\frac{2.04 \text{ mol NaNO}_3}{1 \text{ kg H}_2\text{O}}$ $(204 \text{ mol NaNO}_3) / \left(\frac{85.00 \text{ g}}{1 \text{ mol}}\right) = 173.4 \text{ g NaNO}_3$

mass % = $\frac{173.4 \text{ g NaNO}_3}{1173.4 \text{ g total}} \times 100 = 14.8 \% \text{ NaNO}_3$ $(1000 \text{ g H}_2\text{O}) / \left(\frac{1 \text{ mol}}{18.016 \text{ g}}\right) =$

water + NaNO_3 $X_{\text{NaNO}_3} = \frac{2.04 \text{ mol NaNO}_3}{2.04 \text{ mol} + 55.506 \text{ mol}} = 0.0354$ $55.506 \text{ mol H}_2\text{O}$

vp solution $P_A = X_A P_A^0$ $X_A = \text{mole fraction solvent} = 1 - X_{\text{NaNO}_3} = 0.96455$
 $P_A = (0.96455)(71.88 \text{ torr}) = 69.3 \text{ torr}$

30. 0.18 ppm Li^+ = $\frac{0.18 \text{ g Li}^+}{10^6 \text{ g solution}}$ $(300 \text{ g}) / \left(\frac{0.18 \text{ g Li}^+}{10^6 \text{ g soln}}\right) = 5.4 \times 10^{-5} \text{ g Li}^+$

31. ppm = $\frac{\text{g solute}}{\text{g solution}} \times 10^6 = \frac{0.0052 \text{ g Ag}^+}{3000 \text{ g solution}} \times 10^6 = 1.7 \text{ ppm}$

(9)

decreasing radius: larger \rightarrow smaller

- 32 a. Mg^{2+} , F^- , Na^+
 $12p^+$ $9p^+$ $11p^+$
 $10e^-$ $10e^-$ $10e^-$
- isoelectronic - same #, arrangement of e^- . More p^+ , more pull on e^- cloud, so smaller size.

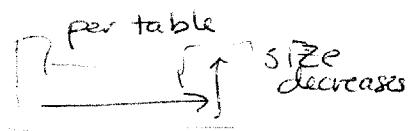
larger F^- , Na^+ , Mg^{2+} smaller

- b. S, S^{2-} , O
comparing S and O S is below O, so larger in size (has larger orbitals occupied)

comparing S and S^{2-} , \ominus ions are larger than corresponding atoms - more e^- , more repulsion.larger S^{2-} , S, O smaller

33. increasing radius smaller \rightarrow larger

smaller F, C, Br, Te, Sr, Cs larger



- Increasing IE smaller atoms have higher IE so opposite order
smaller IE Cs, Sr, Te, Br, C, F larger IE

34. a. $\frac{1L}{1s} \frac{1L}{2s} \frac{1}{2p} \frac{1}{1s} \frac{1}{2s} \frac{1}{2p}$ b. Br $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

- c. Cu $[Ar] 4s^1 3d^{10}$ $\frac{1}{4s} \frac{1L}{3d} \frac{1L}{2s} \frac{1L}{1s} \frac{1L}{2p}$

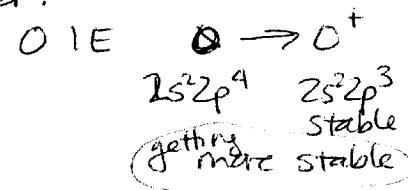
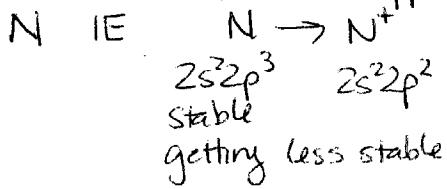
- d. Rh $[Kr] 5s^2 4d^7$ $\frac{1L}{5s} \frac{1L}{4d} \frac{1}{1s} \frac{1}{2s} \frac{1}{2p} \frac{1}{1s}$

- e. $20p^+, 18e^-$ $1s^2 2s^2 2p^6 3s^2 3p^6$

- f. $(Ar) 3d^8$

- g. $8p^+, 10e^-$ $1s^2 2s^2 2p^6$

35. Normally, as you go from left to right on periodic table, IE \rightarrow because size \rightarrow . Here, it's the opposite order.



so this is easier
(requires less energy)

36. $Na \rightarrow Na^+$ $1s^2 2s^2 2p^6 3s^1 \rightarrow 1s^2 2s^2 2p^6$ removing valence e^-

- $Na^+ \rightarrow Na^{2+}$ $1s^2 2s^2 2p^6 \rightarrow 1s^2 2s^2 2p^5$ removing core e^-

- 2nd IE is MUCH higher than 1st IE \nearrow requires much more E than removing valence e^-

(10)

37. Which has most favorable electron affinity? EA ↑ as you go →
 (A) is easiest to add e⁻ to.

38. a. metals - malleable, ductile, shiny, conduct heat + electricity well.
 b. nonmetals - ~~poor~~^{non} conductors, brittle, not shiny
 c. intermediate properties - shiny, poor conductors (^{conduct}a little)
 d. alkali metals - very very reactive - react w/ O₂, H₂O, not found in nature as elements
 e. alkaline earth metals - reactive but not as reactive as group 1A
 f. halogens - diatomic, reactive nonmetals, gain 1 e⁻ easily
 g. noble gases - very unreactive. Don't form compounds
 h. hydrogen - diatomic, gas, forms +1 or -1 ions, can also share
 i. sulfur - S₈(s), yellow, forms rings, reacts w/ O₂ to form SO₂, SO₃; contributes to acid rain
 j. oxygen O₂, O₃ are allotropes O₃ ozone is very reactive O₂ oxidizes other elements

39a. MgCl₂ vs MgBr₂ same charges. Br⁻ is larger in size than Cl⁻; so MgBr₂ will have weaker attractions.

MgCl₂ - higher lattice energy

b. SrI or CaS Sr⁺, I⁻ vs Ca²⁺, S²⁻

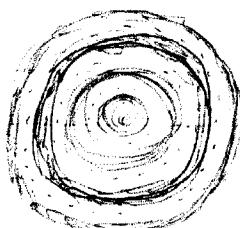
larger ions smaller ions

lower charges higher charges * much larger effect

CaS - higher mp - stronger attractions.

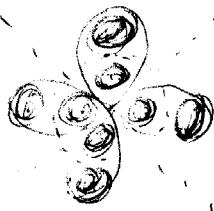
40. 2d and 2f do not exist. For 2d, n=2 and l=2. But according to the rules for quantum numbers, l can't be equal to or larger than n. For 2f, n=2 and l=3. This is impossible for the same reason.

41. 4s n=4 l=0 n-l-1 = 4-0-1 = 3 radial nodes



11

41 4d $n=4, l=2 \quad n-l-1 = 4-2-1 = 1$ radial node



42. a. not allowed. If $l=0$, m_l can't equal 2 - it can only be \emptyset
 $(m_l = 0, \pm 1, \pm 2, \dots, \pm l)$

b. allowed. This is a 3d orbital.

43.

