

# 1 Answers

## 1.1 Unit 1

### Problem 1

The molar mass of  $C_9H_8O_4$  is  $1.008 * 8 + 12.01 * 9 + 16.00 * 4 = 180.2 \frac{g}{mol}$

$$7.89kg \times \frac{1g}{10^{-3}kg} \times \frac{1mol}{180.2g} = 43.8mol \quad (1)$$

### Problem 2

(b), the tallest peak of the graph is the one at  $64u$ .

### Problem 3

In one mole of  $C_{13}H_{18}O_2$  is  $206.31g$ .

$$1mol C_{13}H_{18}O_2 \times \frac{13mol C}{1mol C_{13}H_{18}O_2} \times \frac{12.01g}{1mol C} = 156.31g \quad (2)$$

Thus, the percent composition by weight is  $\frac{156.31}{206.31} = 75.764\%$

### Problem 4

Take  $100g$  of the substance such that there are  $32.38g$  sodium,  $22.65g$  sulfur, and  $44.99g$  oxygen.

$$\begin{aligned} 32.38g Na \times \frac{1mol Na}{22.99g} &= 1.408mol Na \\ 22.65g S \times \frac{1mol S}{32.07g} &= 0.7063mol S \\ 44.99g O \times \frac{1mol O}{16g} &= 2.812mol O \end{aligned} \quad (3)$$

Take the ratio of each compound with the smallest quantity.

$$\begin{aligned} S : \frac{0.7063}{0.7063} &= 1 \\ Na : \frac{1.408}{0.7063} &= 2 \\ O : \frac{2.812}{0.7063} &= 4 \end{aligned} \quad (4)$$

Therefore, the empirical formula is  $Na_2SO_4$

### Problem 5

$$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10}$$

### Problem 6

Be. The peak location of the peak on the x-axis means that there is less binding energy for the electrons in element X. Be has fewer protons and both electrons are in the same shell, so its peak must belong to Be.

### Problem 7

- The electronegativity increases from left to right across a period. This is because if a valence shell of electrons is less than half full then it requires less energy to lose an electron than gain one. If the valence shell of electrons is more than half full, it is easier to pull an electron into the valence shell. The electronegativity decreases from the top to the bottom of a group. This is because there is a greater atomic radius lower on the group.
- The ionization energy increases from left to right in a period. This is because of greater valence shell stability also because of smaller atomic radius. The ionization energy also decreases from top to bottom of a group. This is because of greater electron shielding and greater atomic radius.
- Atomic radius decreases from left to right within a period. This is because there are more protons to the right of the period. Atomic radius increases from top to bottom within a group. This is because of electron shielding and there are more electron shells in the atom.

## 1.2 Unit 2

### Problem 8

The ionic character increases the greater the electronegativity difference. In this case, Na and O had the greatest electronegativity difference.

### Problem 9

(c)  $\text{Cl} - \text{F} > \text{H} - \text{I} > \text{Se} - \text{N}$

### Problem 10

$\text{Cs}^+$  has a larger atomic radius than  $\text{K}^+$ . So the distance between the cation and anion is greater than in CsF than in KF

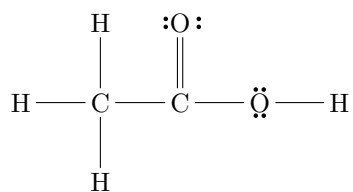
### Problem 11

Most metallic elements form crystalline solids at room temperature. Their bonds are metallic bonds due to electrostatic attraction between metal cations and delocalized electrons.

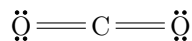
### Problem 12

- Substitutional alloys. These alloys form when one atom of a similar size to the host metal replaces an atom of the host metal. The substitute atom must be of similar size. These alloys have good thermal and electrical conductivity.
- Interstitial alloys. These alloys are formed when smaller atoms fill in the gaps between the larger host atoms. This makes the metal harder and less malleable.

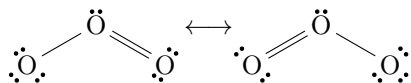
### Problem 13



### Problem 14

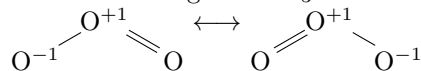


### Problem 15



### Problem 16

All formal charges of  $\text{CH}_3\text{COOH}$  and  $\text{CO}_2$  are zero.



### Problem 17

The electron geometry is tetrahedral. The molecular geometry is trigonal pyramidal. Hybridization of N atom is  $sp^3$  since it has tetrahedral electron geometry.

## 1.3 Unit 3

### Problem 18

Dipole-dipole and London dispersion forces. The  $\text{C}-\text{O}$  bond is polar and the molecule is asymmetrical so it is polar. There are no  $\text{H}-\text{F}$ ,  $\text{H}-\text{O}$ , or  $\text{H}-\text{N}$  bonds, so there is no hydrogen bonding.

**Problem 19**

Condensation. Both have no regular arrangement, the one on the left is separated by the one on the right is close together, so the molecules are transitioning from gas to liquid.

**Problem 20**

(a) As you increase the temperature, the average kinetic energy or speed increases as well.

(b)  $n_1 = n_2$  and  $V_1 = V_2$ , so  $P_1V_1 = n_1RT_1$  and  $P_2V_2 = n_2RT_2$ .  $\frac{P_2V_2}{RT_2} = \frac{P_1V_1}{RT_1} \implies P_2 = \frac{P_1T_2}{T_1} = \frac{0.7 \times 425}{299} = 0.99 \text{ atm}$

(c) As the temperature increases, the average kinetic energy increases, so the molecules undergo more collisions with the walls of the container.

**Problem 21**

$$60.3g \times \frac{1 \text{ mol Ba(OH)}_2}{171.35g} \times \frac{2 \text{ mol OH}^-}{1 \text{ mol Ba(OH)}_2} * \frac{1}{1.75L} = 0.402M$$

**Problem 22**

The photoelectric effect occurs when light of a certain minimum frequency/energy hits the surface of a metal and electrons are ejected.

**Problem 23**

$\text{Ar} < \text{H}_2\text{S} < \text{HCOOH}$

**Problem 24**

London dispersion forces. Benzene is symmetrical so there are no dipole dipole forces.

**Problem 25**

$\text{MgF}_2$

**Problem 26**

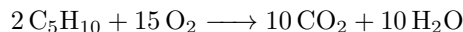
Because  $\text{I}_2$  has a more polarizable electron cloud.

**Problem 27**

No, it is symmetrical.

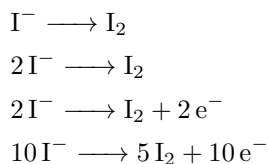
## 1.4 Unit 4

### Problem 28

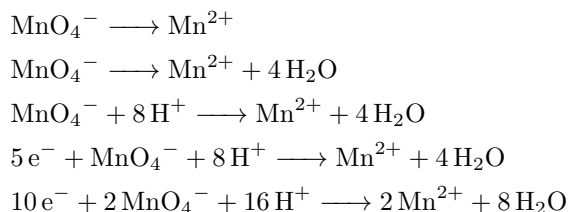


### Problem 29

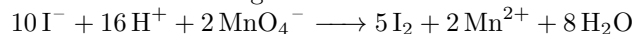
The oxidation reaction:



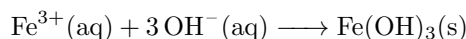
The reduction reaction:



Add the reactions together:



### Problem 30



### Problem 31

Chemical processes are characterized by changes in intramolecular forces, while physical processes are characterized by changes only in intermolecular forces.

### Problem 32

Find the limiting reactant:

$$\begin{aligned}36.0 \text{ gH}_2\text{O} * \frac{1 \text{ molH}_2\text{O}}{18.02 \text{ gH}_2\text{O}} * \frac{1 \text{ molFe}_3\text{O}_4}{4 \text{ molH}_2\text{O}} &= 0.49945 \text{ molFe}_3\text{O}_4 \\ 67.0 \text{ gFe} * \frac{1 \text{ molFe}}{55.85 \text{ gFe}} * \frac{1 \text{ molFe}_3\text{O}_4}{3 \text{ molFe}} &= 0.39988 \text{ molFe}_3\text{O}_4\end{aligned}\tag{5}$$

Therefore, the limiting reactant is Fe<sub>3</sub>

Find how much iron oxide is produced: Use the limiting reactant

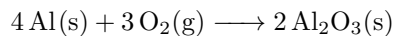
$$0.39988 \text{ molFe}_3 * \frac{231.55 \text{ gFe}_3\text{O}_4}{1 \text{ molFe}_3} = 92.6 \text{ gFe}_3\text{O}_4\tag{6}$$

Find how much excess reactant is left over:

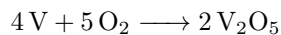
$$67.0 \text{ gFe} * \frac{1 \text{ molFe}}{55.85 \text{ gFe}} * \frac{4 \text{ molH}_2\text{O}}{3 \text{ molFe}} * \frac{18.02 \text{ gH}_2\text{O}}{1 \text{ molH}_2\text{O}} = 28.8 \text{ gH}_2\text{O} \quad (7)$$

28.8 grams of water is used out of 32.0 grams. So there is 7.2 grams left over of the excess reagent.

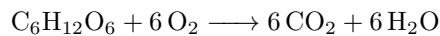
### Problem 33



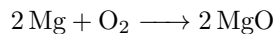
### Problem 34



### Problem 35



### Problem 36



## 1.5 Unit 5

### Problem 37

$$1.5 \times 10^3 \text{ mol}$$

### Problem 38

$$\text{CH}_4 \quad \text{rate} = \frac{-\Delta[\text{CH}_4]}{\Delta t}$$

$$\text{O}_2 \quad \text{rate} = \frac{-1}{2} \frac{\Delta[\text{O}_2]}{\Delta t}$$

$$\text{CO}_2 \quad \text{rate} = \frac{\Delta[\text{CO}_2]}{\Delta t}$$

$$\text{H}_2\text{O} \quad \text{rate} = \frac{1}{2} \frac{\Delta[\text{H}_2\text{O}]}{\Delta t}$$

### Problem 39

$$10 \frac{M}{s}$$

### Problem 40

$$\frac{(0.04-0.1)M}{125ms} \times \frac{1ms}{10^{-3}s} = -0.48 \frac{M}{s}$$

$$\text{rate} = -\frac{1}{2} \times -0.48 = 0.24 \frac{M}{s}$$

**Problem 41**

When concentration of  $B$  is held constant and the concentration of  $A$  is tripled, the initial rate is multiplied by 9 so the order with respect to  $A$  is 2. The order with respect to  $B$  is 0 because nothing changes when the concentration is increased. Thus the rate law is

$$rate = k[A]^2[B]^0 = k[A]^2$$

$$1.0 \times 10^{-2} = k \times 0.1^2 \implies k = 1.0 \frac{1}{ms}, \text{ thus } rate = [A]^2$$

**Problem 42**

$$\ln[A]_t = -kt + \ln[A]_0$$

$$\ln[A]_t = -(4.8 \times 10^{-4})(825) + \ln(0.0165)$$

$$[A]_t = e^{-4.50} = 0.0111M$$

Half-life:

$$\ln\left(\frac{1}{2}[A]_0\right) - \ln[A]_0 = -kt$$

$$\ln\left(\frac{1}{2}\right) = -kt$$

$$t = \frac{\ln(2)}{k}$$

**Problem 43**

$$k = 4.0 \times 10^{-4} \frac{1}{Ms} = 35 \frac{1}{M \times days}$$

$$\frac{1}{[A]_t} = 35 * 6 + \frac{1}{0.1} \implies [A]_t = 4.5 \times 10^{-3}$$

**Problem 44**

$$\frac{1}{0.085M} = 35t + \frac{1}{0.1M} \implies t = 0.05days$$

**Problem 45**

$2H_2O_2 \longrightarrow 2H_2O + O_2$  The rate determining step is the slow reaction, so  
 $rate = k[H_2O_2][I^-]$

$I^-$  is the catalyst.  $IO^-$  is the intermediate.

**Problem 46**

Overall:  $2NO + 2H_2 \longrightarrow 2H_2O + N_2$

Rate determining step:  $rate = k[N_2O_2][H_2]$

Fast equilibrium: rate forward = rate back  $\implies [N_2O_2] = \frac{k_f}{k_r}[NO]^2$

Thus,  $rate = \frac{k_f k_r}{k_r}[NO]^2[H_2]$

## 1.6 Unit 6

### Problem 47

$$50gH_2O \times \frac{1molH_2O}{18.01gH_2O} \times \frac{6.022 \times 10^{23}H_2O}{1molH_2O} \times \frac{2O-H}{1H_2O} \times \frac{1.8 \times 10^{-9}cal}{1O-H} \times \frac{4.184J}{1cal} \times \frac{1kJ}{10^3J} = 2500kJ$$

### Problem 48

$$q_{water} = 7.3 \times 100 \times 4.184$$

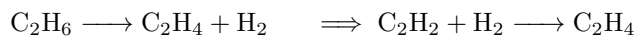
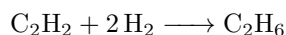
$$q_{water} = -q_{metal}$$

$$q_{metal} = C_{metal}(27.3 - 100) * 120 \implies C_{metal} = 0.350 \frac{J}{g^\circ C}$$

### Problem 49

$$5.0LH_2O \times \frac{1mLH_2O}{10^{-3}LH_2O} \times \frac{1gH_2O}{1mL} \times \frac{1mol}{18.01g} \times \frac{40.72kJ}{1mol} = 11302.32kJ$$

### Problem 50



Thus,  $\Delta H = -175$

### Problem 51

$$1.5molO_2 \times \frac{1mol_{rxn}}{3molO_2} \times \frac{-1371kJ}{mol_{rxn}} = -685.5kJ$$

### Problem 52

Increase

### Problem 53

$$\Delta S = 205.0 + 2 \times 130.58 - 2 \times 188.83 = 88.5 \frac{J}{K}$$

### Problem 54

$$\Delta S_{surr} = \frac{-\Delta H}{T} = -\frac{-802.2 \times 1000}{298.15} = 2691 \frac{J}{K}$$

$$\Delta S_{sys} = 2 \times 188.7 + 213.7 - (186.1 + 2 \times 205.0) = -5.0 \frac{J}{K}$$

$$\Delta S_{universe} = -5 + 2691 = 2686 \frac{J}{K}.$$

### Problem 55

$$\Delta G = -19800J - (1000) * (-197.3 \frac{J}{K}) = 106000J$$

### Problem 56

More product at high temperature



## 1.7 Unit 7

### Problem 57

$$K_c = \frac{[\text{CH}_4][\text{H}_2\text{O}]}{[\text{H}_2]^2[\text{CO}]}$$

### Problem 58

$Q_c = 6.25$ .  $Q_c > K_c$  so the reaction will shift towards reactants.

### Problem 59

$K_p = \frac{(3x)^3 x}{(14-2x)^2} \Rightarrow 2.0 \times 10^{-6} \approx \frac{(3x)^3 x}{14^2} \Rightarrow x = 0.062 \text{ atm}$ . The partial pressure is  $0.062 \text{ atm}$ .

### Problem 60

$x^2 = 0.16 \Rightarrow x = 0.4 \text{ M}$ . Note that  $250 \text{ g} = 4.89 \text{ mol}$  which is clearly enough to produce the  $0.4 \text{ M}$  predicted by the equilibrium constant.

### Problem 61

$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = 1.8 \times 10^{-10} \Rightarrow x^2 = 1.8 \times 10^{-10} \Rightarrow x = 1.3 \times 10^{-5} \text{ M}$$

### Problem 62

$$K_{sp} = [\text{Ca}^{2+}]^3[\text{PO}_4^{3-}]^2 \Rightarrow 108x^5 = 1.2 \times 10^{-29} \Rightarrow x = 6.4 \times 10^{-7} \text{ M}$$

### Problem 63

$$x = 15 \text{ mg} \times \frac{10^{-3} \text{ g}}{1 \text{ mg}} \times \frac{1 \text{ mol}}{78.08 \text{ g}} = 1.9 \times 10^{-4} \text{ M}$$

$$K_{sp} = [\text{Ca}^{2+}][\text{F}^-]^2 = x(2x)^2 = 2.7 \times 10^{-11}$$

### Problem 64

$$1.0 \times 10^{-14} = 1.3[\text{OH}^-] \Rightarrow [\text{OH}^-] = 7.7 \times 10^{-15} \text{ M}$$

### Problem 65

$$\text{pH} = -\log(0.05) = 1.30$$

### Problem 66

HA	H <sub>2</sub> O	H <sub>3</sub> O <sup>+</sup>	A <sup>-</sup>
0.2		~ 0	0
-x		x	x
0.2 - x		~ x	x

$$2.6 \times 10^{-5} = \frac{x^2}{0.2-x} \approx \frac{x^2}{0.2} \Rightarrow x = 0.00228 \Rightarrow \text{pH} = 2.64$$

## 1.8 Unit 8

### Problem 67

$$pH = pK_a + \log\left(\frac{[\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}\right) \implies pH = -\log(1.8 \times 10^{-5}) + \log\left(\frac{0.1}{0.5}\right) \implies pH = 4.04$$

### Problem 68

$$pH = -\log(1.8 \times 10^{-5}) + \log\left(\frac{0.5}{0.1}\right) = 5.44$$

### Problem 69

(c)

### Problem 70

Yes

### Problem 71

Yes, the strong base reacts with half of the weak acid to produce weak base.

### Problem 72

$$[\text{H}_3\text{O}^+] = 10^{-3.7} = 2.0 \times 10^{-4}$$
$$\text{Percent ionization} = \frac{2.0 \times 10^{-4}}{0.1} \times 100 = 0.2\%$$

### Problem 73

HF is weak even though F is highly electronegative because the bond between HF is stronger than the bond between HCl.

### Problem 74

Because the highly electronegative O in the molecule of  $\text{HClO}_4$  pulls away electrons more effectively than the  $\text{HClO}_2$  because  $\text{HClO}_2$  only has 2 electrons. Thus the H—O bond is more polar in  $\text{HClO}_4$

### Problem 75



### Problem 76

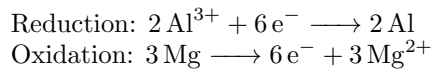
$$1 \times 10^{-7}$$

## 1.9 Unit 9

### Problem 77

Chlorine is oxidized.

### Problem 78

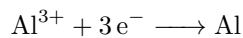


### Problem 79

$$Q = \frac{[\text{Mg}^{2+}]^3}{[\text{Al}^{3+}]^2}$$

$$\text{So } E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{RT}{nF} \ln(Q) = 0.71 - \frac{8.314 \times 298}{6 \times 96485} \times \ln(1 \times 10^4) = 0.67V.$$

### Problem 80



$$q = I \times t = 10C$$

$$n = \frac{q}{F} = \frac{10C}{96485 \frac{C}{mol}} = 1.04 \times 10^{-4} \text{mole}^{-}$$

$$1.04 \times 10^{-4} \text{mole}^{-} \times \frac{1 \text{mol Al}^{3+}}{3 \text{mole}^{-}} \times \frac{26.98g}{1 \text{mol}} = 9.32 \times 10^{-4}g$$