1 Answers

1.1 Unit 1

Problem 1

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

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

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 $206.31g$.

$$1mol\,C_{13}H_{18}O_2 \times \frac{13mol\,C}{1molC_{13}H_{18}O_2} \times \frac{12.01g}{1mol\,C} = 156.31g \tag{2}$$

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.

$$\begin{aligned} 32.38g\,\mathrm{Na} \times \frac{1mol\,\mathrm{Na}}{22.99g} &= 1.408mol\,\mathrm{Na} \\ 22.65\,g\mathrm{S} * \frac{1\,mol\mathrm{S}}{32.07g} &= 0.7063\,mol\mathrm{S} \\ 44.99\,g\mathrm{O} * \frac{1\,mol\mathrm{O}}{16g} &= 2.812\,mol\mathrm{O} \end{aligned} \tag{3}$$

Take the ratio of each compound with the smallest quantity.

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

Therefore, the empirical formula is Na_2SO_4

Problem 5

$1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^{10}5p^66s^24f^{14}5d^{10}$

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 it 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 than it requires less energy to lose an electron than gain one. If 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 beause 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) $\mathrm{Cl} — \mathrm{F} > \mathrm{H} — \mathrm{I} > \mathrm{Se} — \mathrm{N}$

Problem 10

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

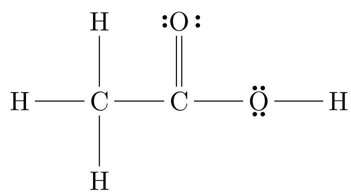
Problem 11

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

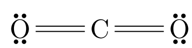
Problem 12

- 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.

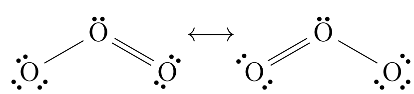
Problem 13



Problem 14

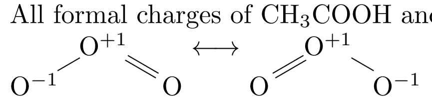


Problem 15



Problem 16

All formal charges of CH_3COOH and 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-diple and london dispersion forces. The C—O bond is polar and the molecule is asymmetrical so it is polar. There are no H—F, H—O, or H—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 $P_2V_2 = n_2RT_2$. $\frac{P_2V_2}{RT_2} = \frac{P_1V_1}{RT_1} \implies P_2 = \frac{P_1T_2}{T_1} = \frac{0.7*425}{299} = 0.99atm$
(c) As the temperature increases, the average kinetic energy increases, so the molecules undergo more collisions with the walls of the container.

Problem 21

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

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

$Ar < H_2S < HCOOH$

Problem 24

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

Problem 25

MgF_2

Problem 26

Because I_2 has a more polarizable electron cloud.

Problem 27

No, it is symmetrical.

1.4 Unit 4

Problem 28

$2\,C_5H_{10} + 15\,O_2 \longrightarrow 10\,CO_2 + 10\,H_2O$

Problem 29

The oxidation reaction:

$$
\begin{aligned}
&I^- \longrightarrow I_2 \\
&2\,I^- \longrightarrow I_2 \\
&2\,I^- \longrightarrow I_2 + 2\,e^- \\
&10\,I^- \longrightarrow 5\,I_2 + 10\,e^-
\end{aligned}
$$

The reduction reaction:

$$
\begin{aligned}
&MnO_4{}^- \longrightarrow Mn^{2+} \\
&MnO_4{}^- \longrightarrow Mn^{2+} + 4\,H_2O \\
&MnO_4{}^- + 8\,H^+ \longrightarrow Mn^{2+} + 4\,H_2O \\
&5\,e^- + MnO_4{}^- + 8\,H^+ \longrightarrow Mn^{2+} + 4\,H_2O \\
&10\,e^- + 2\,MnO_4{}^- + 16\,H^+ \longrightarrow 2\,Mn^{2+} + 8\,H_2O
\end{aligned}
$$

Add the reactions together:
$10\,I^- + 16\,H^+ + 2\,MnO_4{}^- \longrightarrow 5\,I_2 + 2\,Mn^{2+} + 8\,H_2O$

Problem 30

$Fe^{3+}(aq) + 3\,OH^-(aq) \longrightarrow Fe(OH)_3(s)$

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:

$$
\begin{aligned}
36.0\,gH_2O * \frac{1\,molH_2O}{18.02\,gH_2O} * \frac{1\,molFe_3O_4}{4\,molH_2O} &= 0.49945\,molFe_3O_4 \\
67.0\,gFe * \frac{1\,molFe}{55.85\,gFe} * \frac{1\,molFe_3O_4}{3\,molFe} &= 0.39988\,molFe_3O_4
\end{aligned} \tag{5}
$$

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

$$0.39988\,mol\mathrm{Fe} * \frac{231.55\,gFe_3O_4}{1\,mol\mathrm{Fe}} = 92.6\,gFe_3O_4 \tag{6}$$

Find how much excess reactant is left over:

$$67.0\,gFe * \frac{1\,molFe}{55.85\,gFe} * \frac{4\,molH_2O}{3\,molFe} * \frac{18.02\,gH_2O}{1\,molH_2O} = 28.8\,gH_2O \tag{7}$$

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

$4\,\mathrm{Al(s)} + 3\,\mathrm{O_2(g)} \longrightarrow 2\,\mathrm{Al_2O_3(s)}$

Problem 34

$4\,\mathrm{V} + 5\,\mathrm{O_2} \longrightarrow 2\,\mathrm{V_2O_5}$

Problem 35

$\mathrm{C_6H_{12}O_6} + 6\,\mathrm{O_2} \longrightarrow 6\,\mathrm{CO_2} + 6\,\mathrm{H_2O}$

Problem 36

$2\,\mathrm{Mg} + \mathrm{O_2} \longrightarrow 2\,\mathrm{MgO}$

1.5 Unit 5

Problem 37

$1.5 \times 10^3 mol$

Problem 38

$\mathrm{CH_4}$ rate $= \frac{-\Delta[\mathrm{CH_4}]}{\Delta t}$
$\mathrm{O_2}$ rate $= \frac{-1}{2}\frac{\Delta[\mathrm{O_2}]}{\Delta t}$
$\mathrm{CO_2}$ rate $= \frac{\Delta[\mathrm{CO_2}]}{\Delta t}$
$\mathrm{H_2O}$ rate $= \frac{1}{2}\frac{\Delta[\mathrm{H_2O}]}{\Delta t}$

Problem 39

$10\frac{M}{s}$

Problem 40

$\frac{(0.04-0.1)M}{125ms} \times \frac{1ms}{10^{-3}s} = -0.48\frac{M}{s}$
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 concetration is increased. Thus the rate law is

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

$1.0 \times 10^{-2} = k \times 0.1^2 \implies k = 1.0\frac{1}{ms}$, 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:

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

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

$2\,H_2O_2 \longrightarrow 2\,H_2O + O_2$ 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: $2\,NO + 2\,H_2 \longrightarrow 2\,H_2O + N_2$
Rate determining step: $rate = k[N_2O_2][H_2]$
Fast equilbium: rate forward = rate back $\implies$ $[N_2O_2] = \frac{k_f}{k_r}[NO]^2$
Thus, $rate = \frac{kk_f}{k_r}[NO]^2[H_2]$

1.6 Unit 6

Problem 47

$50g\mathrm{H_2O}\times\frac{1mol\mathrm{H_2O}}{18.01g\mathrm{H_2O}}\times\frac{6.022\times10^{23}\mathrm{H_2O}}{1mol\mathrm{H_2O}}\times\frac{2\mathrm{O-H}}{1\mathrm{H_2O}}\times\frac{1.8\times10^{-9}cal}{1\mathrm{O-H}}\times\frac{4.184J}{1cal}\times\frac{1kJ}{10^3J}=2500kJ$

Problem 48

$q_{water}=7.3\times100\times4.184$
$q_{water}=-q_{metal}$
$q_{metal}=C_{metal}(27.3-100)*120 \implies C_{metal}=0.350\frac{J}{g^{\circ}C}$

Problem 49

$5.0L\mathrm{H_2O}\times\frac{1mL\mathrm{H_2O}}{10^{-3}L\mathrm{H_2O}}\times\frac{1g\mathrm{H_2O}}{1mL}\times\frac{1mol}{18.01g}\times\frac{40.72kJ}{1mol}=11302.32kJ$

Problem 50

$$\begin{aligned}&\mathrm{C_2H_2}+2\,\mathrm{H_2}\longrightarrow\mathrm{C_2H_6}\\&\mathrm{C_2H_6}\longrightarrow\mathrm{C_2H_4}+\mathrm{H_2}\qquad\implies\mathrm{C_2H_2}+\mathrm{H_2}\longrightarrow\mathrm{C_2H_4}\end{aligned}$$

Thus, $\Delta H=-175$

Problem 51

$1.5mol\mathrm{O_2}\times\frac{1mol_{rxn}}{3mol\mathrm{O_2}}\times\frac{-1371kJ}{mol_{rxn}}=-685.5kJ$

Problem 52

Increase

Problem 53

$\Delta S=205.0+2\times130.58-2\times188.83=88.5\frac{J}{K}$

Problem 54

$\Delta S_{surr}=\frac{-\Delta H}{T}=-\frac{-802.2*1000}{298.15}=2691\frac{J}{K}$
$\Delta S_{sys}=2\times188.7+213.7-(186.1+2\times205.0)=-5.0\frac{J}{K}$
$\Delta S_{universe}=-5+2691=2686\frac{J}{K}$.

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

$K_c = \frac{[CH_4][H_2O]}{[H_2]^2[CO]}$

Problem 58

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

Problem 59

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

Problem 60

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

Problem 61

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

Problem 62

$K_{sp} = [Ca^{2+}]^3[PO_4{}^{3-}]^2 \implies 108x^5 = 1.2 \times 10^{-29} \implies x = 6.4 \times 10^{-7} M$

Problem 63

$x = 15mg \times \frac{10^{-3}g}{1mg} \times \frac{1mol}{78.08g} = 1.9 \times 10^{-4} M$
$K_{sp} = [Ca^{2+}][F^-]^2 = x(2x)^2 = 2.7 \times 10^{-11}$

Problem 64

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

Problem 65

$pH = -log(0.05) = 1.30$

Problem 66

HA	H_2O	H_3O^+	A^-
0.2		~ 0	0
$-x$		x	x
$0.2 - x$		$\sim x$	x

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

1.8 Unit 8

Problem 67

$pH = pK_a + log(\frac{[\mathrm{CH_3COO}]}{[\mathrm{CH_3COOH}]}) \implies pH = -log(1.8 \times 10^{-5}) + log(\frac{0.1}{0.5}) \implies pH = 4.04$

Problem 68

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

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

$[\mathrm{H_3O^+}] = 10^{-3.7} = 2.0 \times 10^{-4}$
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 $HClO_4$ pulls away electrons more effectively than the $HClO_2$ because $HClO_2$ only has 2 electrons. Thus the H — O bond is more polar in $HClO_4$

Problem 75

$SO_4{}^{2-}$

Problem 76

1×10^{-7}

1.9 Unit 9

Problem 77

Chlorine is oxidized.

Problem 78

Reduction: $2\,Al^{3+} + 6\,e^- \longrightarrow 2\,Al$
Oxidation: $3\,Mg \longrightarrow 6\,e^- + 3\,Mg^{2+}$

Problem 79

$Q = \frac{[Mg^{2+}]^3}{[Al^{3+}]^2}$
So $E_{cell} = E_{cell}{}^{\circ} - \frac{RT}{nF} ln(Q) = 0.71 - \frac{8.314\times298}{6\times96485} \times ln(1\times10^4) = 0.67V$.

Problem 80

$Al^{3+} + 3\,e^- \longrightarrow Al$
$q = I \times t = 10C$
$n = \frac{q}{F} = \frac{10C}{96485\frac{C}{mol}} = 1.04 \times 10^{-4} mol\mathrm{e}^-$
$1.04 \times 10^{-4} mol\mathrm{e}^- \times \frac{1mol\mathrm{Al}^{3+}}{3mol\mathrm{e}^-} \times \frac{26.98g}{1mol} = 9.32 \times 10^{-4} g$