Unit #1 and 2: Matter and Chemical Bonding Review and Chemical Reactions Solutions

MULTIPLE CHOICE: 1.D 2.D 3.A 4.D 5.B 6.A 7.C 8.A 9.E 10.E 11.E

SHORT ANSWER

12. Ionization energy increases because atomic radius decreases. This happens because the nuclear charge increases, but the number of energy levels does not. Therefore, the nucleus has a stronger hold on the electrons as the nuclear charge increases. Therefore more energy is required to remove an electron.

13. helium 14. element Z

15.

oxygen sodium boron neon

16. To obtain a full valence shell, hydrogen atoms will form covalent bonds with one another. Nitrogen will do the same with itself, in order to give each atom a stable octet.

H–H :N≡N:

17.

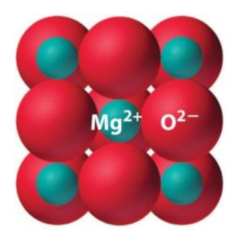
	Aqueous	Non-aqueous
(a) $HClO_{3(aq)}$	chloric acid	hydrogen chlorate
(b) $HNO_{2(aq)}$	nitrous acid	hydrogen nitrite
(c) $HI_{(aq)}$	hydroiodic acid	hydrogen iodide

18. $2Na_{(s)} + 2H_2O_{(l)} \rightarrow H_{2(g)} + 2NaOH_{(aq)}$

19. $Na_2SO_{4(aq)} + Pb(NO_3)_{2(aq)} \rightarrow PbSO_{4(s)} + 2NaNO_{3(aq)}$ Double Displacement Reaction

20. a)-Brittle: if lattice is shifted by an impact, like charges are forced next to each other and repel.

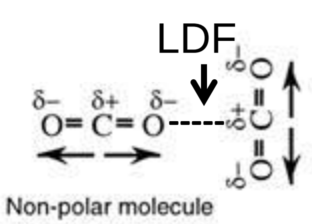
-Relatively strong attraction between ions: the ionic bonds must be overcome to a large degree to break down the crystal lattice and allow the substance to melt.
-Ions arrange themselves so that there is maximum proximity to ions of opposite charge, but maximum distance from ions of same charge. A crystal lattice is formed and ordered particles result in a solid.

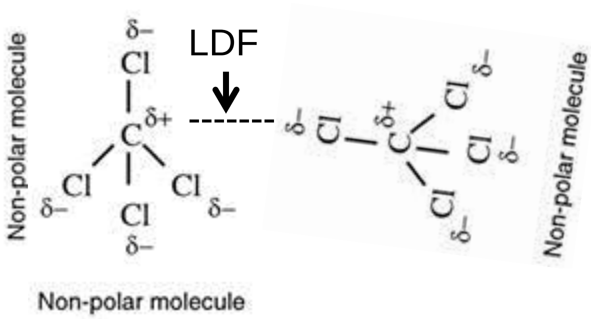


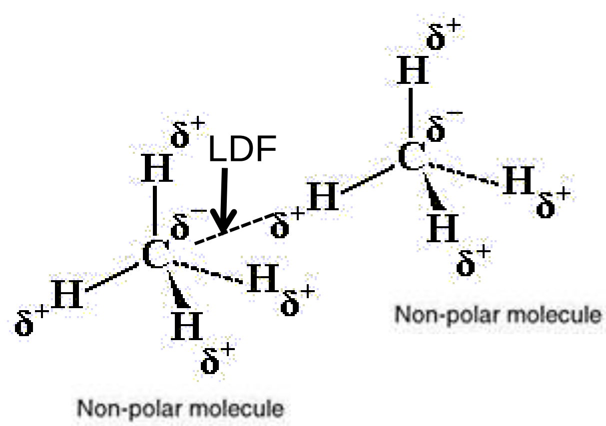
MgO

21. a) CO_2, CH_4, CCl_4 b) HCl, HF, CH_3Cl, H_2O

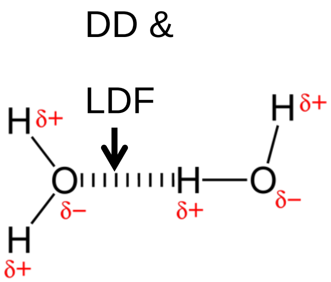
London Dispersion Forces: CO_2, CH_4, CCl_4

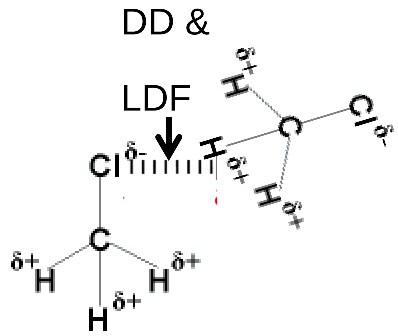




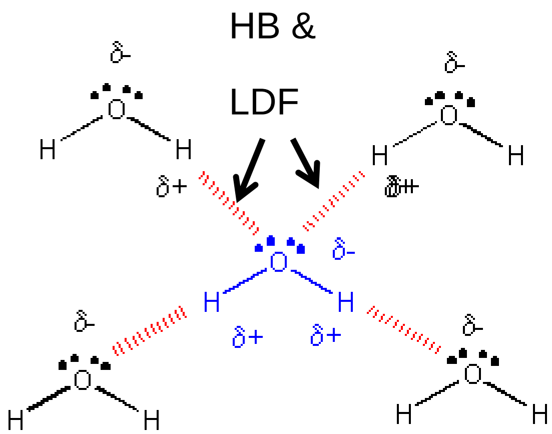


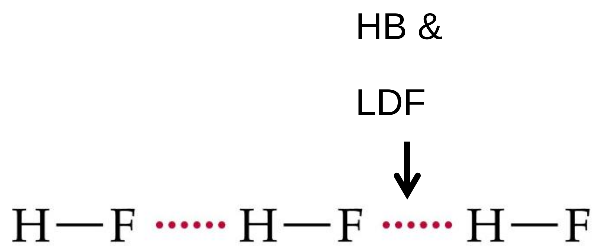
Dipole-dipole Forces and London Dispersion Forces: HCl, CH_3Cl





Hydrogen Bonding and London Dispersion Forces: H_2O, HF





Unit 3: Quantities in Chemical Reactions Review

MULTIPLE CHOICE: 1.B 2.D 3.B 4.D 5.A

PROBLEM

6. m_{Mg} = 24.30 u x 1 atoms = 24.30 u
   m_O = 16.00 u x 2 atoms = 32.00 u
   m_H = 1.01 u x 2 atoms = 2.02 u
   m_{total} = 58.32 u

$$\%Mg = \frac{24.30\ u}{58.32\ u} \times 100\% = 41.67\% \qquad \%O = \frac{32.00\ u}{58.32\ u} \times 100\% = 54.87\% \qquad \%H = \frac{2.02\ u}{58.32\ u} \times 100\% = 3.46\%$$

The percentage composition, by mass, of $Mg(OH)_2$ is 41.67% magnesium, 54.87% oxygen, and 3.46% hydrogen.

7. Assuming 100 g of sample
   C = 10.06 g — M_C = 12.011 g/mol
   Cl = 89.10 g — M_{Cl} = 35.453 g/mol
   H = 0.84 g — M_H = 1.008 g/mol

$$n_C = 10.06\ g \times \frac{1\ mol}{12.011\ g} = 0.84\ mol \qquad n_{Cl} = 89.10\ g \times \frac{1\ mol}{35.453\ g} = 2.51\ mol \qquad n_H = 0.84\ g \times \frac{1\ mol}{1.008\ g} = 0.83\ mol$$

The molar ratio for C:Cl:H is 0.84:2.51:0.83. Dividing by 0.83 to obtain the lowest ratio, we obtain the molar ratio of 1:3:1. The empirical formula of the compound is CCl_3H.

$$\text{empirical formula mass} = 12.01\ \text{u} + (3 \times 3.453\ \text{u}) + 1.008\text{u}$$

$$=$$

$$\frac{\text{molecular mass}}{\text{empirical formula mass}} = \frac{119.6\ \text{u}}{119.378\text{u}}$$

$$= 1$$

The molecular formula of the compound is CCl_3H.

8.

mole ratio: $AlCl_3:NaCl = 1:3$

$$n_{AlCl_3} = 4.46\ \text{g} \times \frac{1\ \text{mol}}{133.341\ \text{g}}$$

$$= 3.34 \times 10^{-2}\ \text{mol}$$

$$n_{NaCl} = 3.34 \times 10^{-2}\ \text{mol AlCl}_3 \times \frac{3\ \text{mol NaCl}}{1\ \text{mol AlCl}_3}$$

$$= 0.100\ \text{mol}$$

$$m_{NaCl} = 0.100\ \text{mol} \times \frac{58.443\ \text{g}}{1\ \text{mol}}$$

$$= 5.86\ \text{mol}$$

The mass of sodium chloride that can be obtained is 5.86 g.

9. We can determine the number of moles of chlorine needed to react completely with 15.9 g of Na.

$$n_{Na} = 15.9\ \text{g} \times \frac{1\ \text{mol}}{22.99\ \text{g}}$$

$$= 0.692\ \text{mol}$$

mole ratio: $Na:Cl_2 = 2:1$

$$n_{Cl_2}\ \text{needed} = 0.692\ \text{mol Na} \times \frac{1\ \text{mol Cl}_2}{2\ \text{mol Na}}$$

$$= 0.346\ \text{mol}$$

$$n_{Cl_2}\ \text{available} = 27.4\ \text{g} \times \frac{1\ \text{mol}}{70.906\ \text{g}}$$

$$= 0.386\ \text{mol}$$

More chlorine is available than is required, therefore, chlorine is in excess. The sodium is the limiting reagent.

$$n_{Na} = 0.692\ \text{mol}$$

mole ratio: $Na:NaCl = 1:1$

$$n_{NaCl} = n_{Na}$$

$$= 0.692\ \text{mol}$$

$$m_{NaCl} = 0.692\ \text{mol} \times \frac{58.44\ \text{g}}{1\ \text{mol}}$$

$$= 40.4\ \text{g}$$

The theoretical yield of the NaCl is 40.4 g.

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

$$= \frac{36.9 \text{ g}}{40.4 \text{ g}} \times 100\%$$

$$= 91.3\%$$

The percentage yield is 91.3%.

Unit 4: Solutions and Solubility Review Solutions

MULTIPLE CHOICE: 1.E 2.A 3.B 4.E 5.C 6.A

PROBLEM

7. $m_{Na_3PO_4} = 150.0 \text{ g}$

$C_{Na_3PO_4} = 0.23 \text{ mol/L}$

$M_{Na_3PO_4} = 163.94 \text{ g/mol}$

$$n_{Na_3PO_4} = 150.0 \text{ g} \times \frac{1 \text{ mol}}{163.94 \text{ g}} = 0.9150 \text{ mol}$$

$$v_{Na_3PO_4} = \frac{0.9150 \text{ mol}}{0.23 \text{ mol/L}} = 4.0 \text{ L}$$

The volume of the solution will be 4.0 L.

8. $v_f = 2.0 \text{ L}$

$C_i = 17.4 \text{ mol/L}$

$C_f = 1.5 \text{ mol/L}$

$$v_i C_i = v_f C_f$$

$$v_{i\,(\text{acetic acid})} = \frac{v_f C_f}{C_i}$$

$$= \frac{2.0 \text{ L} \times 1.5 \text{ mol/L}}{17.4 \text{ mol/L}}$$

$$= 1.7 \times 10^{-1} \text{ L}$$

$$= 1.7 \times 10^{2} \text{ mL}$$

The volume of the stock acetic solution needed is 1.7 x 10^2 mL.

9. $Na_2C_2O_{4(s)} \rightarrow 2Na^+_{(aq)} + C_2O_4{}^{2-}_{(aq)}$

$m = 8.50 \text{ g}$

$v = 500 \text{ mL}$

$$n_{Na_2C_2O_{4(s)}} = 8.50 \text{ g} \times \frac{1 \text{ mol}}{133.998 \text{ g}} = 0.0634 \text{ mol}$$

$$C_{Na_2C_2O_{4(s)}} = \frac{0.0634 \text{ mol}}{0.500 \text{ L}} = 0.127 \text{ mol/L}$$

$$[Na^+_{(aq)}] = 2 \times 0.127 \text{ mol/L} = 0.25 \text{ mol/L}$$

The sodium ion concentration is 0.25 mol/L.

$$[C_2O_4{}^{2-}_{(aq)}] = 0.13 \text{ mol/L}$$

The oxalate ion concentration is 0.13 mol/L.

10. $3BaCl_{2(aq)} + Fe_2(SO_4)_{3(aq)} \rightarrow 3BaSO_{4(s)} + 2FeCl_{3(aq)}$

$3BaCl_{2(aq)}$	$Fe_2(SO_4)_{3(aq)}$	$3BaSO_{4(s)}$
100.0 mL	100.0 mL	2.0g
0.100 mol/L	0.100 mol/L	

$$n_{BaSO_4} = 0.100\text{ L} \times 0.100\text{ mol/L BaCl}_2 \times \frac{3\text{ mol BaSO}_4}{3\text{ mol BaCl}_2}$$

$$= 0.01\text{ mol}$$

$$m_{BaSO_4} = 0.01\text{ mol} \times \frac{233.888\text{ g}}{1\text{ mol}}$$

$$= 2.3\text{ g}$$

The theoretical mass of barium sulfate is 2.3 g.

$$\%\text{ yield BaSO}_4 = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$= \frac{2.0\text{ g}}{2.3\text{ g}} \times 100$$

$$= 86\%$$

The % yield of the barium sulfate precipitate was 86%.

11. $$[H^+_{(aq)}] = 10^{-pH}$$

$$= 10^{-7.5}\text{ mol/L}$$

$$= 3.2 \times 10^{-8}\text{ mol/L}$$

The hydrogen ion concentration of the swimming pool is 3.2 x 10^{-8} mol/L.

12. $H_2SO_{4(aq)}$ + $2NaOH_{(aq)}$ → $Na_2SO_{4(aq)}$ + $2H_2O_{(l)}$

10.00 mL	8.66 mL		
C?	0.00512 mol/L		

$$n_{NaOH} = 8.66\text{ mL} \times \frac{0.0512\text{ mol}}{1\text{ L}}$$

$$= 0.4434\text{ mmol}$$

$$n_{H_2SO_4} = 0.4434\text{ mmol} \times \frac{1}{2}$$

$$= 0.2217\text{ mmol}$$

$$C_{H_2SO_4} = \frac{0.2217\text{ mmol}}{10.00\text{ mL}}$$

$$= 0.02217\text{ mol/L}$$

The sulfuric acid concentration in the lake is 0.0222 mol/L.

H_2SO_4 (aq) → 2 H+ (aq) + SO_4^{2-} (aq)

[H+] = 2 (0.02217 mol/L)

pH = -log[H+]

= -log (2x0.02217)

= 1.35

The pH of the lake water is 1.35.

13. $$pH = -\log [H^+_{(aq)}]$$

$$= -\log [3.12 \times 10^{-5}]$$

$$= 4.506$$

The pH of beer is 4.51.

Unit 5: Gases Review Solutions

MULTIPLE CHOICE: 1.E 2.B 3.B 4.A

PROBLEM

5. V_1 = 375 mL P_2 = 95.5 kPa V_2 = 1.25 L P_1 = ?

Convert mL to L for V_1: $V_1 = 375 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}}$

$= 0.375 \text{ L}$

$$P_1V_1 = P_2V_2$$

$$P_1 = \frac{P_2V_2}{V_1}$$

$$= \frac{95.5 \text{ kPa} \times 1.25 \text{ L}}{0.375 \text{ L}}$$

$$= 318 \text{ kPa}$$

The pressure of the gas was 318 kPa.

6. m = 3.45 g T = 273 K P = 101.325 kPa R = 8.31 kPa L/mol K V = ?

Convert mass to moles of CO_2: $\text{number of moles of } CO_2 = \frac{3.45 \text{ g} \times 1 \text{ mol } CO_2}{44.009 \text{ g}}$

$= 0.0784 \text{ mol}$

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

$$= \frac{0.0784 \text{ mol} \times 8.31 \text{ kPa L/mol K} \times 273.15 \text{ K}}{101.325 \text{ kPa}}$$

$$= 1.76 \text{ L}$$

The volume occupied by the CO_2 is 1.76 L.

7.

P_1	V_1	T_1	P_2	V_2	T_2
95.5 kPa	15.5 L	245ºC + 273.15 = 518.15 K	107 kPa	20.5 L	?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$T \text{ in } °C = 768 \text{ K} - 273 = 495°C$

$$T_2 = \frac{P_2V_2T_1}{P_1V_1}$$

$$= \frac{107 \text{ kPa} \times 2.5 \text{ L} \times 518.15 \text{ K}}{95.5 \text{ kPa} \times 15.5 \text{ L}}$$

$$= 768 \text{ K}$$

The new temperature will be 495ºC.

8.

P	*V*	*n*	*R*	*T*
?	2.25 L	?	8.31 kPa L/mol K	27ºC + 273.15 = 300.15 K

$$\text{number of moles of Xe} = 75.0\ \text{g} \times \frac{1\ \text{mol Xe}}{131.3\ \text{g}}$$

$$= 0.571\ \text{mol}$$

$$PV = nRT$$

$$P = \frac{nRT}{V}$$

$$= \frac{0.571\ \text{mol Xe} \times 8.31\ \text{kPa L/mol K} \times 300.15\ \text{K}}{2.25\ \text{L}}$$

$$= 634\ \text{kPa}$$

The pressure in the flask will be 634 kPa.

9. *P* = 101.325 kPa
T = 273 K
V = 15.5 L
R = 8.31 kPa L/mol K
n = ?

$$PV = nRT$$

$$n = \frac{PV}{RT}$$

$$= \frac{101.325\ \text{kPa} \times 15.5\ \text{L}}{8.31\ \text{kPa L/mol K} \times 273.15\ \text{K}}$$

$$= 0.692\ \text{mol C}_2\text{H}_2$$

$$\text{number of moles of CO}_2 = 0.692\ \text{mol C}_2\text{H}_2 \times \frac{4\ \text{mol CO}_2}{2\ \text{mol C}_2\text{H}_2}$$

$$= 1.384\ \text{mol CO}_2$$

$$\text{mass of CO}_2 = 1.38\ \text{mol} \times \frac{44.009\ \text{g}}{1\ \text{mol CO}_2}$$

$$= 60.9\ \text{g}$$

The mass of CO_2 will be 60.9 g, regardless of the temperature or pressure.