Name Key

Unit 4 Review – Chemical Change

1. Balance the following equations:

a. 4 NO + 6 H_2O → 4 NH_3 + 5 O_2

b. 3 $(NH_4)_2Cr_2O_7$ + 2 $AlCl_3$ → $Al_2(Cr_2O_7)_3$ + 6 NH_4Cl

c. $C_{17}H_{36}$ + 26 O_2 → 17 CO_2 + 18 H_2O

d. 2 Co + 3 H_2SO_4 → $Co_2(SO_4)_3$ + 3 H_2

e. P_4 + 6 Cl_2 → 4 PCl_3

f. 2 H_3PO_4 + 3 $Ba(OH)_2$ → $Ba_3(PO_4)_2$ + 6 H_2O

g. 2 $Al(CH_3COO)_3$ → 2 Al + 12 C + 9 H_2 + 6 O_2

2. **Complete, balance** and **classify** the following equations as *synthesis, decomposition, single replacement, double replacement, neutralization* or *combustion.*

a. 2 Al + 3 $Zn(NO_3)_2$ → 2 $Al(NO_3)_3$ + 3 Zn

Reaction Type Single replacement

b. 2 C_6H_{14} + 19 O_2 → 12 CO_2 + 14 H_2O

Reaction Type Combustion

c. 2 Na_3PO_4 + 3 $Ca(NO_3)_2$ → $Ca_3(PO_4)_2$ + 6 $NaNO_3$

Reaction Type double replacement

d. $Mg(H_2PO_4)_2$ → Mg + 2 H_2PO_4

Reaction Type decomposition

e. Cl_2 + 2 KI → 2 KCl + I_2

Reaction Type single replacement

f. 2 Al + 3 F_2 → 2 AlF_3

Reaction Type Synthesis

g. $Zn + Cu(ClO_3)_2 \rightarrow Zn(ClO_3)_2 + Cu$

Reaction Type: single replacement.

h. $2Co(NO_3)_3 + 3(NH_4)_2C_2O_4 \rightarrow 6NH_4NO_3 + Co_2(C_2O_4)_3$

Reaction Type: double replacement

i. $C_{12}H_{25}OH + 18O_2 \rightarrow 12CO_2 + 13H_2O$

Reaction Type: Combustion

j. $Sr(OH)_2 + 2HNO_3 \rightarrow Sr(NO_3)_2 + 2H_2O$

Reaction Type: neutralization

k. $4V + 5O_2 \rightarrow 2V_2O_5$ (Assume combining capacity of V is 5+)

Reaction Type: Synthesis

l. $Rb_3AsO_4 \rightarrow 3Rb + AsO_4$

Reaction Type: decomposition

m. $3CsOH + H_3PO_4 \rightarrow Cs_3PO_4 + 3H_2O$

Reaction Type: neutralization

n. $3Ni(NO_3)_2 + 2(NH_4)_3PO_4 \rightarrow Ni_3(PO_4)_2 + 6NH_4NO_3$

Reaction Type: double replacement

o. $2Al + 3H_2CO_3 \rightarrow Al_2(CO_3)_3 + 3H_2$

Reaction Type: Single replacement

p. $MgSO_4 + 2AgNO_3 \rightarrow Ag_2SO_4 + Mg(NO_3)_2$

Reaction Type: double replacement

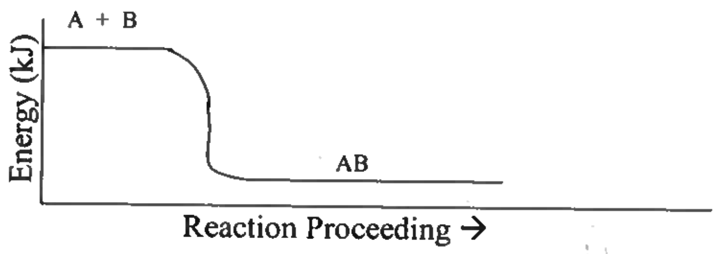
3. State whether each of the following are ***exothermic*** or ***endothermic***.

a. $HCl + 432\ kJ \rightarrow H + Cl$ Answer endo

b. $C_{12}H_{22}O_{11} + 12\ O_2 \rightarrow 12CO_2 + 11H_2O + 5638\ kJ$ Answer exo

c. $H_2O_{(l)}$ +heat $\rightarrow H_2O_{(g)}$ Answer endo

d.



Answer exo

e. $C + D \rightarrow CD$ $\Delta H = +65.7\ kJ$ Answer endo

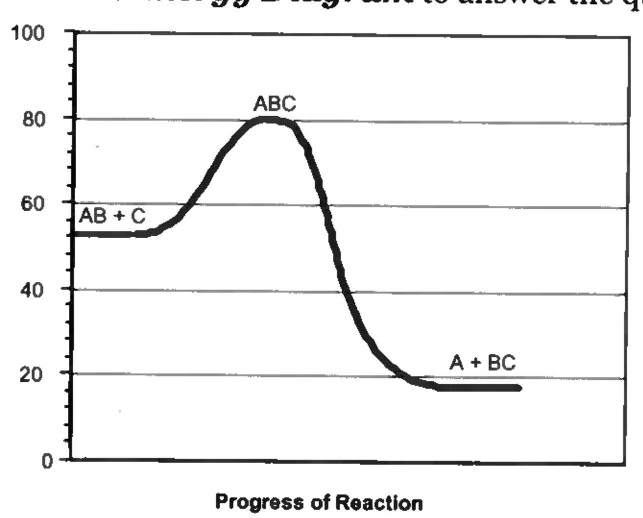
f. $E + F \rightarrow G +$ $\Delta H = -437\ kJ$ Answer exo

4. In an ***exothermic*** reaction, the surroundings get (*warmer*/*cooler*)

5. Define ***enthalpy***

heat energy contained in the bonds of molecules

6. Use the following ***Potential Energy Diagram*** to answer the questions below:



a) Determine the ***Activation Energy*** for the *forward* reaction... 80-52 +28 kJ

b) Determine the ***Activation Energy*** for the *reverse* reaction.... 80-16 +64 kJ

c) What is the ***Enthalpy Change*** (ΔH) for the *forward* reaction?.. 52-16 -36 kJ

d) What is the ***Enthalpy Change*** (ΔH) for the *reverse* reaction?.. +36 kJ

e) The *forward* reaction is exo thermic.

f) The *reverse* reaction is endo thermic.

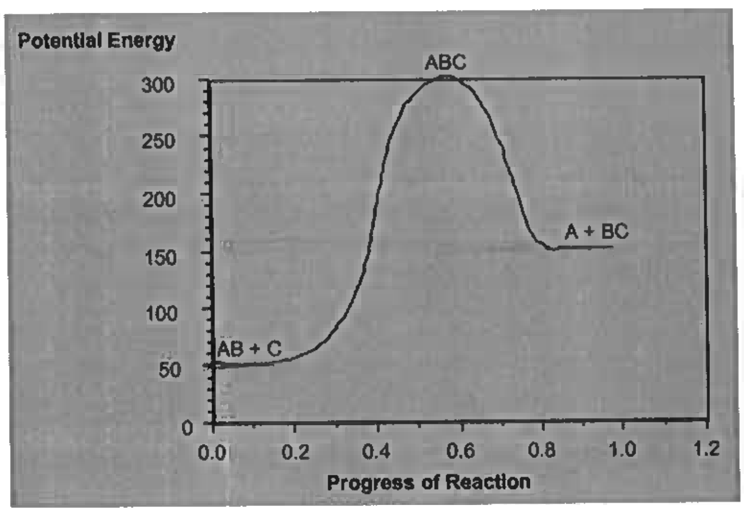
g) Which species or set of species forms the ***Activated Complex***? AB+C collide

h) What is the formula for the activated complex? ABC

7. State the meaning of ***Activation Energy***

Energy required to break necessary bonds in the reactants and form the activated complex

8. Use the following ***Potential Energy Diagram*** to answer the questions below:



a) Determine the ***Activation Energy*** for the *forward* reaction... +250

b) Determine the ***Activation Energy*** for the *reverse* reaction.... +150

c) What is the ***Enthalpy Change*** (ΔH) for the *forward* reaction?.. +100

d) What is the ***Enthalpy Change*** (ΔH) for the *reverse* reaction?.. -100

e) The *forward* reaction is endo thermic.

f) The *reverse* reaction is exo thermic.

g) Which species or set of species forms the ***Activated Complex***?

AB+C collide to make ABC

9. Given the balanced equation:

$$2\,Si_4H_{10\,(l)} + 13\,O_{2\,(g)} \rightarrow 8\,SiO_{2\,(aq)} + 10\,H_2O_{(g)}$$

a) What volume of oxygen (STP) is required to react with 204.0 g of Si_4H_{10}?

$x\,L\,O_2 = 204g\,Si_4H_{10} \times \frac{1\,mol}{122.4g} \times \frac{13\,O_2}{2\,Si_4H_{10}} \times \frac{22.4L}{1\,mol} = 242.7\,L\,O_2$

b) What mass of SiO_2 is formed when 345.0 g of H_2O are formed?

$x\,g\,SiO_2 = 345.0g\,H_2O \times \frac{1\,mol\,H_2O}{18g} \times \frac{8\,SiO_2}{10\,H_2O} \times \frac{60.1\,g}{1\,SiO_2} = 921.5g\,SiO_2$

c) How many molecules of H_2O are formed when 17.92 L of O_2 are used at STP?

$x\,molec\,H_2O = 17.92L\,O_2 \times \frac{1\,mol\,O_2}{22.4L} \times \frac{10\,H_2O}{13\,O_2} \times \frac{6.022\times10^{23}}{1\,mol} = 3.705\times10^{23}$ molec. H_2

d) What is the concentration of 25.0 mL SiO_2 if 250.0 mL of 1.78M Si_4H_{10} is reacted?

$x\,\frac{mol}{L}\,SiO_2 = 0.250\,L \times \frac{1.78\,mol\,Si_4H_{10}}{1L} \times \frac{8\,SiO_2}{2\,Si_4H_{10}} = 1.78\,mol$

$\frac{1.78\,mol}{0.025\,L} = 71.2\,mol/L$

10. Given the balanced equation:

$$Al_2C_6 + 6\,H_2O \rightarrow 2\,Al(OH)_3 + 3CH_{4\,(g)}$$

a) If 34.5 grams of Al_2C_6 is mixed with 72.0 grams of water, which reactant is in excess? Show by calculations.

$x\,mol\,Al(OH)_3 = 34.5g\,Al_2C_6 \times \frac{1\,mol}{126g} \times \frac{2\,Al(OH)_3}{1\,Al_2C_6} = 0.548\,mol\,Al(OH)_3$

$x\,mol\,Al(OH)_3 = 34.5g\,H_2O \times \frac{1\,mol}{18\,g} \times \frac{2\,Al(OH)_3}{6\,H_2O} = 0.639\,mol\,Al(OH)_3$

H_2O is in excess

same amounts as A. → b) If 34.5 grams of Al_2C_6 is mixed with 72.0 grams of water, what mass of $Al(OH)_3$ is formed? *use limiting reagent to calc.

$0.548\,mol\,Al(OH)_3 \times \frac{78\,g}{1\,mol} =$ 42.7g $Al(OH)_3$ formed.

amt made in part A.

c) If 34.5 grams of Al_2C_6 is mixed with 72.0 grams of water, what volume of CH_4 is formed at STP? *use limiting reagent.

$x\,L\,CH_4 = 34.5g\,Al_2C_6 \times \frac{1\,mol}{126g} \times \frac{3\,CH_4}{1\,Al_2C_6} \times \frac{22.4L}{1\,mol} = 18.4\,L\,CH_4$

11. Given the equation: $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$
When 51.0 grams of NH_3 is burned in an excess of oxygen, 52.65 g of water are produced.

a) Calculate the theoretical yield of H_2O.

$x\,g\,H_2O = 51\,g\,NH_3 \times \frac{1\,mol}{17\,g} \times \frac{6\,H_2O}{4\,NH_3} \times \frac{18\,g}{1\,mol} = 81\,g\,H_2O$

b) Calculate the % yield of H_2O.

$\frac{52.65}{81} \times 100\% = 65\%$

12. Given the equation: $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

When 4.0 grams of hydrogen is combined with an excess of nitrogen, a 92% yield of NH_3 is obtained.

a) Calculate the theoretical yield of NH_3

$x\,g\,NH_3 = 4\,g\,H_2 \times \frac{1\,mol}{2\,g} \times \frac{2\,NH_3}{3\,H_2} \times \frac{17\,g}{1\,mol} = 22.6$

$23\,g\,NH_3$

b) Calculate the actual yield of NH_3

$\frac{actual}{23} \times 0.92$

actual = 21.16

$21\,g\,NH_3$

13. Given the balanced equation:

$3\ HCl_{(aq)} + Fe(OH)_{3\,(aq)} \rightarrow 3\ H_2O_{(l)} + FeCl_{3\,(aq)}$

a) It takes 19.56 mL of 0.50 M HCl to titrate a 25.0 mL sample of a solution of $Fe(OH)_3$. Calculate the $[Fe(OH)_3]$

$x\,mol\,Fe(OH)_3 = 0.01956\,L \times \frac{0.5\,mol}{1\,L} \times \frac{1\,Fe(OH)_3}{3\,HCl} = 3.26 \times 10^{-3}\,mol$

$x\,\frac{mol}{L}\,Fe(OH)_3 = \frac{3.26 \times 10^{-3}}{0.025} = 0.13\,mol/L\,Fe(OH)_3$

b) What mass of $Fe(OH)_3$ is needed to completely react with 10.0 mL of 0.50M HCl solution?

$x\,g\,Fe(OH)_3 = 0.01\,L \times \frac{0.5\,mol\,HCl}{1\,L} \times \frac{1\,Fe(OH)_3}{3\,mol\,HCl} \times \frac{106.8\,g}{1\,mol} = 0.178\,g$

$= 0.18\,g\,Fe(OH)_3$

c) What volume of 0.50M HCl is required to titrate a 21.36 gram sample of iron (III) hydroxide?

$x\,L\,HCl = 21.36\,g\,Fe(OH)_3 \times \frac{1\,mol}{106.8\,g} \times \frac{3\,HCl}{1\,Fe(OH)_3} \times \frac{1\,L}{0.5\,mol} = 1.2\,L$

$1.2\,L\,HCl$

14. Given the following balanced equation, answer the questions below it.

$$2C_6H_{14(l)} + 19O_{2(g)} \rightarrow 12CO_{2(g)} + 14H_2O_{(l)}$$

a. If 299.05 g of C_6H_{14} is mixed with 920.0 grams of oxygen gas, which reactant is limiting?

$x \text{ mol } CO_2 = 299.05 \text{ g } C_6H_{14} \times \frac{1 \text{ mol}}{86 \text{ g}} \times \frac{12 CO_2}{2 C_6H_{14}} = 20.864 \text{ mol } CO_2$

$x \text{ mol } CO_2 =$ ~~299.05 g C6H14~~ 920.0 g O_2 $\times \frac{1 \text{ mol}}{32 \text{ g}} \times \frac{12 CO_2}{19 O_2} =$ ~~24.64 mol CO2~~ 18.16 mol CO_2

~~C6H14~~ O_2 is limiting

b. How much is the other reactant in excess?

~~x mol O2 = 20.864 mol CO2 × 19 / 12 CO2~~

$x \text{ g } C_6H_{14} = 18.16 \text{ mol } CO_2 \times \frac{2 C_6H_{14}}{12 CO_2} \times \frac{86 \text{ g}}{1 C_6H_{14}} = 260.3 \text{ g } C_6H_{14}$ used.

$299.05 - 260.3 = 38.75 \text{ g } C_6H_{14}$ in excess.