Unit 4 Multiple Choice Practice

1. Which of the following is true for an endothermic reaction?
   a. The activation energy is always greater than the activation energy for an exothermic reaction.
   b. Energy is released over the course of the reaction.
   (c.) The strength of the bonds in the reactants exceeds the strength of the bonds in the products.
   d. The products have more thermal energy than the reactants.

2. If the standard enthalpy of formation for HBr(g) is −35 kJ mol^{-1}, what is $\Delta H°_f$ for $Br_2(g)$? not ϕ, b/c Br_2 is liquid at std. (25°C) conditions

$$H_2(g) + Br_2(g) \rightarrow 2\ HBr(g) \quad \Delta H_{rxn} = -110\ \text{kJ mol}^{-1}$$

   a. 0 kJ mol^{-1} b. −40. kJ mol^{-1} (c.) +40. kJ mol^{-1} d. +75 kJ mol^{-1}

$\Delta H_{rxn} = \Sigma \Delta H_f(pr) - \Sigma \Delta H_f(re)$

$-110 = [2(HBr)] - [H_2 + Br_2]$

$= 2(-35) - Br_2$

$\Delta H_f(Br_2) = 110 - 2(35)$

$$MgO(s) \rightarrow Mg^{2+}(aq) + O^{2-}(aq)$$

3. Is the process above endothermic or exothermic? Why?
   a. Exothermic, because one solid particle becomes two aqueous particles.
   b. Endothermic, because one solid particle becomes two aqueous particles.
   c. Exothermic, because overcoming the Coulombic forces within MgO(s) releases energy.
   (d.) Endothermic, because overcoming the Coulombic forces within MgO(s) requires the input of energy.

↖ "ending bonds" = "end"othermic

4. Consider the following reaction showing photosynthesis: reverse rxn!

$$6\ CO_2(g) + 6\ H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6\ O_2(g) \qquad \Delta H = +2800\ \text{kJ/mol}$$

How much thermal energy is absorbed or released when 2.0 moles of glucose, $C_6H_{12}O_6(s)$, is metabolized in the presence of excess oxygen gas, releasing CO_2 and H_2O?

   a. 2800 kJ absorbed b. 5600 kJ absorbed c. 2800 kJ released (d.) 5600 kJ released

$2.0\ \text{mol}\ C_6H_{12}O_6 \times \dfrac{-2800\ \text{kJ}}{1\ \text{mol}\ C_6H_{12}O_6} = -5{,}600\ \text{kJ}$

b/c reversed!

Use the following information to answer the next three questions.

$$3\,H_2(g) + N_2(g) \rightarrow 2\,NH_3(g) \quad \Delta H = -81.0\ \text{kJ/mol}$$

5. Gaseous hydrogen and nitrogen combine in the reaction above to form ammonia, NH_3. What is the value of the heat of formation of $NH_3(g)$?

(a.) −40.5 kJ/mol b. −81.0 kJ/mol c. +40.5 kJ/mol d. +81.0 kJ/mol

ΔH_f° ⇒ make 1 mole! $\frac{3}{2}H_2 + \frac{1}{2}N_2 \rightarrow NH_3$ $\left(\frac{1}{2}\text{ rxn}\right)$

$\frac{-81.0}{2} = -40.5$

6. If 28.0 g of $N_2(g)$ is combined with 28.0 g of $H_2(g)$ in a sealed flask and the reaction is allowed to go to completion, what chemical species will still be present inside of the flask?

a. $NH_3(g)$ only (c.) $NH_3(g)$ and $H_2(g)$

b. $NH_3(g)$ and $N_2(g)$ d. $NH_3(g)$, $N_2(g)$ and $H_2(g)$

$28\ g\ N_2 \times \frac{1\ mol}{28\ g} = 1\ mol\ N_2 \times \frac{1\ mol_{rxn}}{1\ mol\ N_2} = 1\ mol_{rxn}$ ⇒ N_2 limiting ⇒ all used up!

$28\ g\ H_2 \times \frac{1\ mol}{2\ g} = 14\ mol\ H_2 \times \frac{1\ mol_{rx}}{3\ mol\ H_2} \approx 4.7\ mol_{rxn}$ ⇒ H_2 excess ⇒ some left over in flask

7. If 28.0 g of $N_2(g)$ is combined with 28.0 g of $H_2(g)$ in a sealed flask and the reaction is allowed to go to completion, how much heat is absorbed or released?

a. 81.0 kJ absorbed b. 375 kJ absorbed (c.) 81.0 kJ released d. 375 kJ released

N_2 limiting ⇒ $1\ mol\ N_2 \times \frac{-81.0\ kJ}{1\ mol\ N_2} = -81\ kJ$

$$H_2O(l) \rightarrow H_2O(s)$$

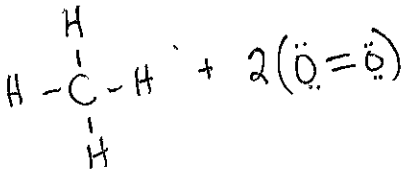
8. Is the process above endothermic or exothermic? Why?

(a.) Exothermic, because forming new intermolecular attractions between water molecules releases energy.

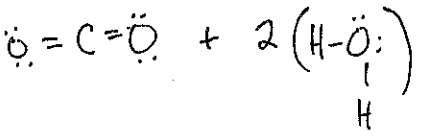
b. Endothermic, because energy is needed to form new intermolecular attractions between water molecules.

c. Exothermic, because forming new bonds between water molecules releases energy.

d. Endothermic, because energy is needed to form new bonds between water molecules.



Bond	Average Bond Dissociation Energy (kJ/mol)
C – H	415
O = O	495
C = O	798
O – H	463



$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$$

9. Use the information provided above to calculate the molar enthalpy of combustion, $\Delta H°_{comb}$, for methane gas.

(a.) −798 kJ mol^{-1} b. −1226 kJ mol^{-1} c. +798 kJ mol^{-1} d. +1226 kJ mol^{-1}

$\Delta H°_{comb}$ = BE (react) − BE (prod)

= [4(C-H) + 2(O=O)] − [2(C=O) + 4(O-H)]

= [4(415) + 2(495)] − [2(798) + 4(463)]

= 2650 − 3448 = −798

$$2\,H_2O(l) \rightarrow 2\,H_2(g) + O_2(g)$$

10. Based on the information in the table below, calculate $\Delta H°_{rxn}$ for the reaction shown above.

Bond	Average Bond Dissociation Energy (kJ/mol)
H – H	430
O = O	500
O – H	460

a. −900 kJ mol^{-1} b. −480 kJ mol^{-1} (c.) +480 kJ mol^{-1} d. +900 kJ mol^{-1}

$\Delta H°_{rxn}$ = BE(react) − BE(prod)

= [4(O-H)] − [2(H-H) + (O=O)]

= 4(460) − [2(430) + (500)] = 1840 − 1360 = 480

$$F(g) + e^- \rightarrow F^-(g)$$

11. Is the process above endothermic or exothermic? Why?

(a.) Exothermic, because of the attraction between F(g) and an electron.

b. Endothermic, because of the attraction between F(g) and an electron.

c. Exothermic, because the process decreases the total number of particles from two to one.

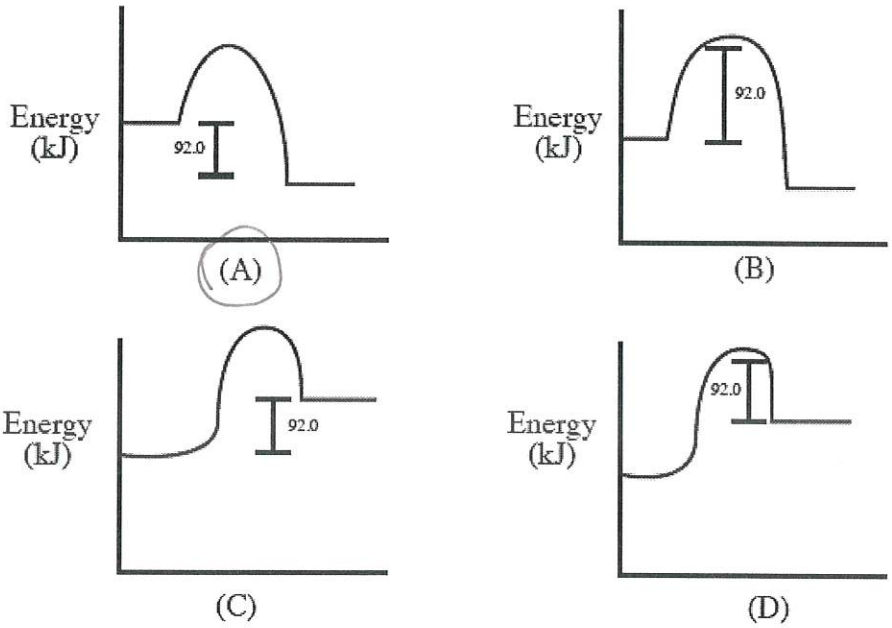
d. Endothermic, because the process decreases the total number of particles from two to one.

12. When ammonium nitrate (NH_4NO_3) dissolves in water, the temperature of the water decreases dramatically. During this reaction, energy transfers from:

a. the reactants to the products.
b. the reactants to the surroundings.
c. the surroundings to the system.
d. the products to the surroundings.

$$CS_2(l) \rightarrow C(s) + 2\,S(s) \qquad \Delta H = -92.0\ \text{kJ/mol}$$

13. Which of the following energy level diagrams gives an accurate representation of the above reaction?



$$CS_2(l) \rightarrow C(s) + 2\,S(s) \qquad \Delta H = -92.0\ \text{kJ/mol}$$

14. Regarding the reaction above, how much heat is absorbed or released when 1.0 mol of solid carbon reacts with 1.0 mol of solid sulfur to produce $CS_2(l)$? ⇒ flip rxn!

a. 46 kJ of heat is released.
b. 46 kJ of heat is absorbed.
c. 92 kJ of heat is released.
d. 92 kJ of heat is absorbed.

$C + 2S \rightarrow CS_2 \quad \Delta H = +92.0\ \text{kJ/mol}$

1 mol, 1 mol

limiting!

15. $1.0\ \text{mol S} \times \frac{+92.0\ \text{kJ}}{2\ \text{mol S}} = +46\ \text{kJ}$

16. The enthalpy change for which of the following reactions would be equal to the enthalpy of formation for ethanol (CH_3CH_2OH)?

a. $CH_3 + CH_2 + OH \rightarrow CH_3CH_2OH$
c. $2\,C + 6\,H + O \rightarrow CH_3CH_2OH$
b. $4\,C + 6\,H_2 + O_2 \rightarrow 2\,CH_3CH_2OH$
(d.) $2\,C + 3\,H_2 + \frac{1}{2}\,O_2 \rightarrow CH_3CH_2OH$

$100.\,mL \times 1M = 100\ mmol_{rxn}$ ← limiting!

$HCOOH + NaOH \rightarrow H_2O + NaCOOH$

17. Inside a calorimeter, 100. mL of 1.0 M formic acid (HCOOH), a weak acid, and 100. mL of 2.0 M sodium hydroxide, NaOH, are mixed. The specific heat of the mixture is approximately 4.2 J/g°C, and the density is identical to that of water. If the temperature of the combined solution rises 8.0°C during the course of the reaction, calculate the approximate amount of heat released. ⇒ q_{rxn}

a. 0.84 kJ b. 3.4 kJ (c.) 6.7 kJ d. 11.8 kJ

$q_{rxn} = -q_{cal} = -mC\Delta T = -(200.\,g)(4.2\,\frac{J}{g°C})(8.0°C) = -6{,}700\,J \times \frac{1\,kJ}{1000\,J} = -6.7\,kJ$

100. mL + 100. mL

released

18. **Consider the previous question.** If the experiment is repeated with 150. mL of 1.0 M HCOOH and 50.0 mL of 2.0 M NaOH, what would happen to the values for ΔT and ΔH_{rxn}?

limiting.

	ΔT	ΔH_{rxn}
(A)	Increase	Increase
(B)	Stay the same	Stay the same
(C)	Decrease	Stay the same
(D)	Stay the same	Increase

$50.0 \times 2.0 = 100\ mmol_{rxn}$] same as previous

⇒ q_{rxn} stays the same

* $m = 200.\,g$] same as previous