SCH4U1 Name:
ER01 Date:

Energy Changes in Chemical Reactions - Worksheet - ANSWERS

Part 1

1. Classify these reactions as exothermic of endothermic:
   a. energy + SO_2 (g) → S (g) + O_2 (g) — Endothermic
   b. C_8H_{18} (g) + O_2 (g) → CO_2 (g) + H_2O (g) + energy — Exothermic
   c. energy + P_4O_{10} (s) → P_4 (s) + 5 O_2 (g) — Endothermic
   d. Mg (s) + H_2SO_4 (aq) → $MgSO_4$ (aq) + H_2 (g) + energy — Exothermic

2. Which reactions below are endothermic? c, i, k are endothermic
   a. Ba (s) + O_2 (g) → BaO_2 (s) + energy
   b. PCl_3 (s) + Cl_2 (g) → PCl_5 (s) + energy
   c. 2 Sb (s) + 3 I_2 (s) + energy → 2 SbI_3 (s)
   d. C_3H_8 (g) + O_2 (g) → CO_2 (g) + H_2O (g)
   e. H_3PO_4 (aq) + LiOH (aq) → Li_3PO_4 (aq) + H_2O (l) + energy
   f. Fe (s) + $CuSO_4$ (aq) → $FeSO_4$ (aq) + Cu (s) + energy
   g. CS_2 (g) + O_2 (g) → CO_2 (g) + SO_2 (g) + energy
   h. NH_3 (g) + HCl (g) → NH_4 Cl (s) + energy
   i. $CaCO_3$ (s) + energy → CaO (s) + CO_2 (g)
   j. Mg (s) + $CrCl_3$ (aq) → $MgCl_2$ (aq) + Cr (s) + energy
   k. KNO_3 (s) + energy → KNO_2 (s) + O_2 (g)
   l. $Pb(NO_3)_2$ (aq) + Na_2SO_4 (aq) → $PbSO_4$ (s) + $NaNO_3$ (aq) + energy
   m. HNO_3 (aq) + LiOH (aq) → $LiNO_3$ (aq) + H_2O (l) + energy
   n. KBr (aq) + $AgNO_3$ (aq) → AgBr (s) + KNO_3 (aq) + energy

3. Is the melting of ice an endothermic change or an exothermic change?
   Endothermic - heat energy is required to raise the temperature of the ice to reach the melting point.

4. In photosynthesis, plants convert the sun's energy into sugars in the reaction:
   6 CO_2 (g) + 6 H_2O (l) → $C_6H_{12}O_6$ (s) + 6 O_2 (g)
   a. Is this reaction exothermic or endothermic?
      Endothermic - energy is a reactant
   b. What is the sign of the ΔH for this reaction?
      ΔH would be "+"

5. Dry ice is solid carbon dioxide. It does not "melt" but instead turns from a solid into a gas in a process called sublimation.
   a. Is this change exothermic or endothermic? Endothermic - energy is required
   b. What sign would the ΔH value have? ΔH would be "+"

6. For the following reaction:
   S (s) + O_2 (g) → SO_2 (g) $\Delta H = -297\ kJ/mol$
   a. Is the reaction exothermic or endothermic? Exothermic - since ΔH is negative
   b. How does the heat content of 1 mole of SO_2 compare to that of 1 mole of S plus 1 mole of O_2? Since the reaction is exothermic the heat content of the products is less than the heat content of the reactants.
      $H(products) < H(reactants)$

7. Determine the ΔH for the formation of one mole of each product in each of the following equations.
   a. 2 C (s) + 3 H_2 (g) + $\frac{1}{2}O_2$ (g) → C_2H_5OH (l) + 235 kJ
      $\Delta H = -235\ kJ/mol$
   b. 2 C (s) + H_2 (g) + 227 kJ → C_2H_2 (g)
      $\Delta H = +227\ kJ/mol$
   c. 2 Ba (s) + O_2 (g) → 2 BaO (s) + 1115 kJ
      $\Delta H = -557.5\ kJ/mol$
   d. I_2 (s) + Br_2 (l) + 81.5 kJ → 2 IBr (g)
      $\Delta H = +40.8\ kJ/mol$

8. This energy from the combustion of hydrazine, N_2H_4, is used to power rockets into space in the reaction:
   N_2H_4 (g) + O_2 (g) → N_2 (g) + 2 H_2O (l) $\Delta H = -627.6\ kJ/mol$
   How many kilograms of hydrazine would be necessary to produce $1.0 \times 10^8 kJ$ of energy? $5.1 \times 10^6 g = 5.1 \times 10^3 kg$

9. A simple fat molecule has the formula $C_3H_5(OH)_2OCO(CH_2)_2CH_3$. The heat of reaction when it is combusted to CO_2 and H_2O is 6405 kJ/mol. Find the amount of energy released per gram of fat. Compare it to the amount of energy released when a carbohydrate is burned (15.6 kJ/g). Which provides more energy per gram?
   Fat 39.49 kJ/g Thus, fat provides more energy per gram than carbohydrates.

10. The amount of solar radiation received annually in a certain location is about $8.4 \times 10^6 kJ/m^2$. How much coke (C) must be burned to carbon dioxide in the following reaction to produce the same amount of energy?
    C (s) + O_2 (g) → CO_2 (g) $\Delta H = -393.7\ kJ/mol$
    $2.6 \times 10^5 g$

Part 2

1. Solid ammonium nitrite decomposes to form nitrogen gas and water vapour. The decomposition releases 224 kJ per mole of ammonium nitrite decomposed.
   a. Write the balanced equation for this reaction including the energy term in the equation.
      $NH_4NO_2(s) \rightarrow N_2(g) + 2\,H_2O\,(g) + 224\ kJ$

   b. Write the balanced equation for the reaction and use Δ*H* notation for the energy term.
      $NH_4NO_2(s) \rightarrow N_2(g) + 2\,H_2O\,(g) \qquad \Delta H_{rxn} = -224\ kJ$

2. Consider the combustion of nitrogen monoxide:
   NO(g) + ½ O_2(g) ⟶ NO_2 (g) Δ*H* = -56.5 kJ/mol
   How much heat would be released by the combustion of 65 g of NO (g)?
   $1.2 \times 10^2\ kJ$

3. Consider the double displacement reaction:

   $Na_2O(s) + 2HI(g) \longrightarrow 2NaI(s) + H_2O(1)$ ΔH = - 502.1 kJ/mol

   If 9.00 g of NaI(s) are formed by this process, how much heat will be released?

   $15.1\ kJ$

4. Consider the decomposition reaction:

   $2NaHSO_4(s) \longrightarrow Na_2SO_4(s) + H_2O(g) + S0_3(g)$ ΔH = +231 kJ/mol

   If 3.60 g of $NaHSO_4$ react, how much heat would be absorbed?

   $3.46\ kJ$

5. Consider the combustion of carbon:

   $C(s) + O_2(g) \longrightarrow CO_2(g)$ ΔH = - 393 kJ/mol

   a. How many grams of carbon must be burned to produce 2556 kJ of energy?

      $78.0g$

   b. How many grams of oxygen gas would have to react in order to produce 2556 kJ of energy?

      $208g$