KEY

Chemistry 30: Diploma Review
Thermochemistry Review WS

Knowledge
30–A1.1k Recall the application of $Q = mc\Delta t$ to the analysis of heat transfer.

1. What does each of the variables in the formula Q = mcΔt represent?

2. 10.0 g of aluminum undergoes an increase in temperature of 4.5 °C. How much energy did the lead absorb?

$Q = mc\Delta t$

$= (10.0\,g)(0.897\,J/g\cdot°C)(4.5°C) = 40.365\,J = 40.4\,J$

$= 40\,J$

3. A tin can gains 140 J of energy and changes temperature from 25.5 °C to 28.5°C. What is the mass of the tin can?

$m = \frac{Q}{c\Delta t} = \frac{140\,J}{(0.227\,J/g\cdot°C)(3.0°C)} = 205.58\,g$

$= 206\,g$

Diploma Question Example:

4. When a 25.0 g sample of a metal is heated from 20.0 °C to 50.0 °C, 178 J of energy is absorbed from the surroundings. The specific heat capacity of the metal is
   A. 7.12 J/g•°C B. 0.356 J/g•°C C. 0.237 J/g•°C D. 0.142 J/g•°C

$C = \frac{Q}{m\Delta t} = \frac{178\,J}{(25.0\,g)(30.0°C)} = 0.237\,J/g\cdot°C$

Knowledge

30–A1.2k Explain, in a general way, how stored energy in the chemical bonds of hydrocarbons originated from the sun.

5. In a few sentences describe how the chemical energy stored in fossil fuels originated in the sun.

Diploma Question Example:

Use the following information to answer the next question.

Processes
1 Combustion
2 Photosynthesis
3 Bacterial decay
4 Energy from the sun

6. From the formation of methane to its eventual use as automobile fuel, the order of the processes listed above is 4, 2, 3, and 1.

Knowledge

30–A1.3k Define enthalpy and molar enthalpy for chemical reactions.

7. What does each of the variables in the formula $\Delta_r H = n\Delta_r H_m$ represent?

8. What does the term molar enthalpy of reaction refer to?

amount of energy gained/lost per mole of ____.

9. If a reaction has a postitive enthalpy change value it absorb energy.

   If a reaction has a negative enthalpy change it release energy.

10. Decane has a molar enthalpy of combustion of -2950 kJ/mol. If 20g of decane is combusted, what is the enthalpy change for the reaction?

$C_{10}H_{22}$ $n = \frac{m}{M} = \frac{20\,g}{142.32\,g/mol} = 0.1405\,mol$

$\Delta_r H = n\,\Delta_r H_m$

$= (0.1405\,mol)(-2950\,kJ/mol)$

$= -414.55\,kJ/mol$

$= -0.41\,MJ/mol$

Diploma Question Example:

11. If 44.7 kJ of energy is transferred when 1.65 g of ethanal, $CH_3CHO_{(l)}$, is burned in a calorimeter, then the molar enthalpy of combustion of ethanal is

A. – 1.67 kJ/mol
B. -7.38×10^1 kJ/mol
C. -2.71×10^1 kJ/mol
D. -1.19×10^3 kJ/mol

$\Delta_r H = 44.7\,kJ$

$m = 1.65\,g$

$M = 44.06\,g/mol$

$\Delta_r H_m = \frac{\Delta_r H}{n} = \frac{44.7\,kJ}{(1.65\,g/44.06\,g/mol)} = 1193.6...$

Knowledge

30–A1.4k Write balanced equations for chemical reactions that include energy changes.

12. If a reaction is endothermic, energy is a reactant in the reaction.

    If a reaction is exothermic, energy is a product in the reaction.

13. Liquid water has a molar enthalpy of formation of -285.8 kJ/mol. Write a balanced chemical formula including energy as a term in the reaction.

$2H_{2(g)} + 1O_{2(g)} \rightarrow 2H_2O_{(l)} + 571.6\ kJ$

14. The molar enthalpy of combustion for carbon fuel (C(s)) is -393.5 kJ /mol. Write a balanced thermochemical reaction showing energy outside the equation.

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} \qquad \Delta_r H = -393.5\ kJ$

Diploma Question Example:

Use the following information to answer the next question.

$$Al_4C_{3(s)} + 12H_2O_{(l)} \rightarrow 4Al(OH)_{3(s)} + 3CH_{4(g)} \qquad \Delta H = -1763.0\ kJ$$

15. If this equation is rewritten to show the production of one mole of $CH_{4(g)}$ and the energy is expressed as a term in the equation, then the energy will be
    A. 587.7 kJ on the reactant side
    B. 1763.0 kJ on the reactant side
    C. 587.7 kJ on the product side
    D. 1763.0 kJ on the product side

Knowledge

30–A1.5k Use and interpret ΔH notation to communicate and calculate energy changes in chemical reactions.

16. The energy released when 0.500 mol of $AgI_{(s)}$ is formed from its elements is _____ kJ.

$\Delta_r H = n \Delta_r H_m = (0.500\ mol)(-61.8) = -30.9\ kJ/mol$

Use the following information to answer the next question.

The combustion of sucrose can be represented by the following equation.

$C_{12}H_{22}O_{11}(s) + 12\,O_2(g) \rightarrow 12\,CO_2(g) + 11\,H_2O(g) \qquad \Delta H° = -5\,155.7\ kJ$

17. If 1.00 g of sucrose reacts as represented by the equation above, then__i__of energy is__ii__ the surroundings.

$n = \frac{m}{M} = \frac{1.00\ g}{} = 0.002\,92...\ mol$

$\Delta_r H = n \Delta_r H_m$

$= (0.002...\ mol)(-5155.7\ kJ/mol)$

$= -15.1\ kJ$

$\Delta_r H_m = \frac{\Delta_r H}{n}$

$= \frac{-5155.7\ kJ}{1\ mol} = -5155.7\ kJ/mol$

The statement above is completed by the information in row

ROW	i	ii
A.	15.1 kJ	absorbed from
B.	15.1 kJ	released to
C.	0.0664 kJ	absorbed from
D.	0.0664 kJ	released to

Use the following information to answer the next question.

A student made the following four statements about a chemical reaction.

I The reaction is exothermic.
II The reaction has a negative ΔH value.
III The reaction warms up the surroundings.
IV The enthalpy of the products is greater than that of the reactants.

18. Which statement is not consistent with the other three?

A. Statement I
B. Statement II
C. Statement III
D. Statement IV

Knowledge

30–A1.6k Predict the enthalpy change for chemical equations using standard enthalpies of formation.

19. Methanol burns in a complete combustion reaction and produces energy used to fuel many small heaters.

Write the balanced chemical reaction for the complete combustion of methanol and calculate the molar enthalpy of combustion for methanol.

$1\,CH_3OH_{(l)} + \frac{3}{2}\,O_{2(g)} \longrightarrow 1\,CO_{2(g)} + 2\,H_2O_{(g)}$

$\Delta_r H = [(1\,mol)(-393.5\,kJ/mol) + (2\,mol)(-241.8\,kJ/mol)] - [(1\,mol)(-239.2\,kJ/mol)]$

$\Delta_r H = -637.9\,kJ$

$\Delta_r H_m = \frac{\Delta_r H}{n} = \frac{-637.9\,kJ}{1\,mol} = -637.9\,kJ/mol$

20. In industry, ethanol is produced by a catalyzed reaction between ethene and water. The equation and energy associated with this reaction can be represented as

A. $C_2H_{4(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)} + 87.6\ kJ$

B. $C_2H_{4(g)} + H_2O_{(l)} + 43.6\ kJ \rightarrow C_2H_5OH_{(l)}$

C. $C_2H_{4(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)}$ $\Delta H = +87.6\ kJ$

D. $C_2H_{4(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)}$ $\Delta H = -43.6\ kJ$

Use the following information to answer the next question.

Standard Heats of Formation

Substance	ΔH_f° (kJ/mol)
X	–22.5
Y	+78.3
Z	–54.8

Given: $X + 3Y \rightleftharpoons 2Z + 2W$ $\Delta H = -562.0\ kJ$

21. The standard molar heat of formation of substance W is

A. + 442.0 kJ/mol

B. – 120.0 kJ/mol

C. – 240.0 kJ/mol

D. – 451.4 kJ/mol

$-562.0\,kJ = [(2\,mol)(\Delta_f H_m \text{ of } W) + (2\,mol)(-54.8\,kJ/mol)] - [(1\,mol)(-22.5\,kJ/mol) + (3\,mol)(+78.3\,kJ/mol)]$

Knowledge

30–A1.7k Explain and use Hess' law to calculate energy changes for a net reaction from a series of reactions.

Use the following equations to answer the next question.

Flip	$C_3H_6(g) + \frac{9}{2}O_2(g) \rightarrow 3\,CO_2(g) + 3\,H_2O(l)$	$\Delta H° = -1\,959.2$ kJ
(x 3)	$C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H° = -393.5$ kJ
$(x \frac{3}{2})$	$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(l)$	$\Delta H° = -571.6$ kJ

+1959.2
- 1180.5
- 857.7
- 78.7 kJ

22. The molar enthalpy of formation of cyclopropane, $3\,C_{(s)} + 3H_{2(g)} \rightarrow C_3H_{6(g)}$, is +/- 78.7 kJ/mol

Knowledge

30–A1.8k Use calorimetry data to determine the enthalpy changes in chemical reactions.

23. What are a few assumptions that we make while doing calorimetry?

24. In an experiment, a student heated 500 g of water from 25.0°C to 91.0°C using 0.133 mol of ethanol. If it is assumed that all the heat energy was absorbed by the calorimeter water, the experimental molar enthalpy of combustion for ethanol was +/- 1.04 MJ/mol.

(Record your three-digit answer in the numerical-response section on the answer sheet.)

$\Delta_r H = q$

$n\Delta_r H_m = mc\Delta t$

$\Delta_r H_m = \frac{mc\Delta t}{n} = \frac{(500\,g)(4.19\,J/g\cdot°C)(66.00°C)}{0.133\,mol}$

$= 1039624\,J/mol$ $= 1.04\,MJ/mol$

Use the following information to answer the next question.

A student uses an aluminium calorimeter to determine the molar enthalpy of solution for solid ammonium nitrate. The student assumes that the calorimeter neither gains nor loses heat during the experiment; that the density and specific heat capacity for the final solution are the same as those of water; and that the mass of the final solution is 150.00 g. The data were collected and recorded in the following table.

Mass of aluminium calorimeter	25.45 g
Mass of aluminium calorimeter and contents	175.45 g
Mass of ammonium nitrate	1.68 g
Initial temperature of calorimeter and contents	22.30 °C
Final temperature of calorimeter and contents	20.98 °C

25. The molar enthalpy of solution for ammonium nitrate in the calorimetry experiment is 39.5 kJ/mol.

$n = \frac{m}{M} = \frac{1.68}{80.06}$

$= 0.02098$

$\Delta_r H = q$

$n\Delta_r H_m = mc\Delta t$

$\Delta_r H_m = \frac{mc\Delta t}{n} = \frac{(150_g)(4.19\ J/g \cdot °C)(1.32)}{}$

$= 39535.4\ J/mol$

$= +39.54\ kJ/mol$

Use the following information to answer the next question.

Two fuels that can be used in camping stoves are gasoline (assume pure octane) and propane.

26. Design a calorimetry experiment that would allow you to choose the best fuel to use for heating water on a camping stove.

Your response should include
- a detailed procedure → determine the amount of energy released by each fuel by burning 50mL in identical calorimeters → observe + record ΔH.
- identification of the controlled, manipulated, and responding variables
  - → controlled – same volume, calorimeter, type of
  - → manipulated – the two fuels
  - → responding – enthalpy changes for each fuel
- two reasons to support your choice of the best fuel
  - → determine which has > molar enthalpy

Knowledge

30–A1.9k Identify that liquid water and carbon dioxide gas are reactants in photosynthesis and products of cellular respiration and that gaseous water and carbon dioxide gas are the products of hydrocarbon combustion in an open system.

27. The products of photosynthesis are__i__, and the products of hydrocarbon combustion are__ii__.
The statement above is completed by the information in row

ROW	i	ii
A.	$CO_{2(g)}$ and $H_2O_{(l)}$	$CO_{2(g)}$ and $H_2O_{(g)}$
B.	$CO_{2(g)}$ and $H_2O_{(l)}$	$CO_{2(g)}$ and $H_2O_{(l)}$
(C.)	$C_6H_{12}O_{6(s)}$ and $O_{2(g)}$	$CO_{2(g)}$ and $H_2O_{(g)}$
D.	$C_6H_{12}O_{6(s)}$ and $O_{2(g)}$	$CO_{2(g)}$ and $H_2O_{(l)}$

Use the following information to answer the first question.

In most plants, solar energy, water, and carbon dioxide react to form glucose. The reaction is represented by the equation

$$6\,CO_{2(g)} + 6\,H_2O_{(l)} + \text{energy} \rightarrow C_6H_{12}O_{6(aq)} + 6\,O_{2(g)}$$

28. This reaction is an example of
A. respiration
(B) photosynthesis
C. redox and neutralization
D. combustion and respiration

Knowledge

30–A1.10k Classify chemical reactions as endothermic or exothermic, including those for the processes of photosynthesis, cellular respiration and hydrocarbon combustion.

Use the following information to answer the next question.

Type of Reaction

1 Endothermic
2 Exothermic

29. Match the type of reaction numbered above with the reactions given below.

Photosynthesis ___1___ (Record in the first box)
Cellular respiration ___2___ (Record in the second box)
Formation of glucose ___2___ (Record in the third box)
Combustion of propane ___2___ (Record in the fourth box)

Knowledge
30–A2.1k Define activation energy as the energy barrier that must be overcome for a chemical reaction to occur.

Knowledge
30–A2.2k Explain the energy changes that occur during chemical reactions, referring to bonds breaking and forming and changes in potential and kinetic energy.

Knowledge
30–A2.3k Analyze and label energy diagrams of a chemical reaction, including reactants, products, enthalpy change and activation energy.

30. Define activation energy.

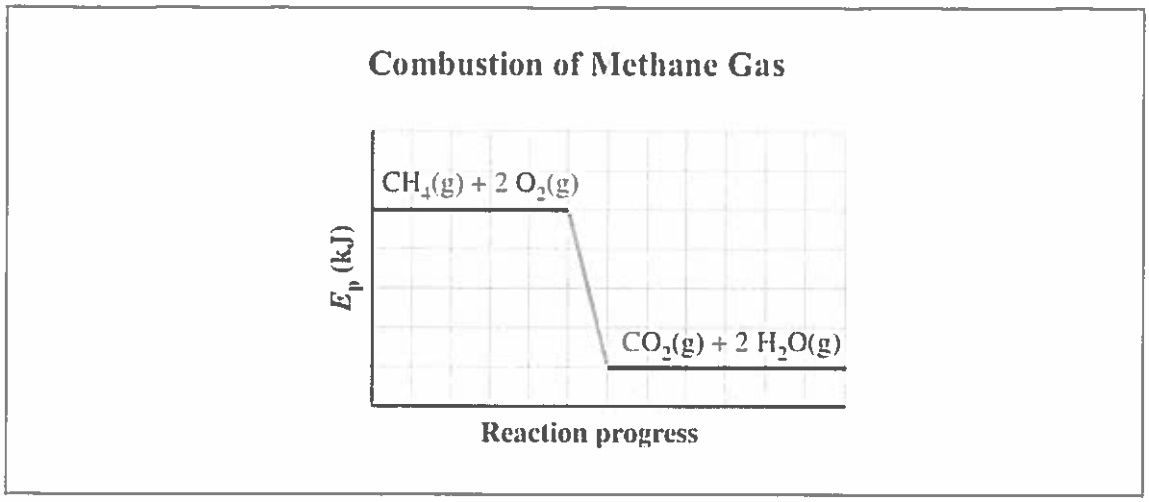
31. Why is it correct to say that every chemical reaction absorbs **and** releases energy?

32. The energy changes that occur when propane undergoes combustion are primarily due to changes in__i__ energy resulting from__ii__.

The statement above is completed by the information in row

ROW	i	ii
A.	potential	a rearrangement of bonds
B.	potential	an increase in molecular motion
C.	kinetic	a rearrangement of bonds
D.	kinetic	an increase in molecular motion

Use the following diagram to answer the next question.



33. According to the diagram above, the enthalpy change for the combustion of 1.00 mol of methane gas is
    A. endothermic and represented by a negative ΔH value
    B. endothermic and represented by a positive ΔH value
    C. exothermic and represented by a negative ΔH value
    D. exothermic and represented by a positive ΔH value

Knowledge

30–A2.4k Explain that catalysts increase reaction rates by providing alternate pathways for changes, without affecting the net amount of energy involved; *e.g., enzymes in living systems.*

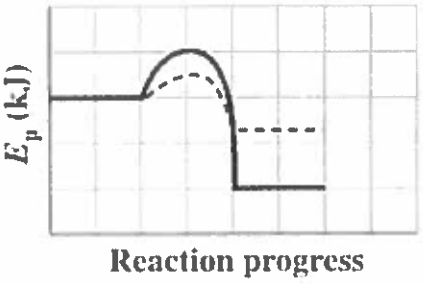
Use the following information to answer the next question.

One of the byproducts of the cracking process used at oil-refining plants is ethyne, $C_2H_2(g)$. In the presence of a palladium catalyst, the ethyne forms ethene and ethane, as represented by the following equation.

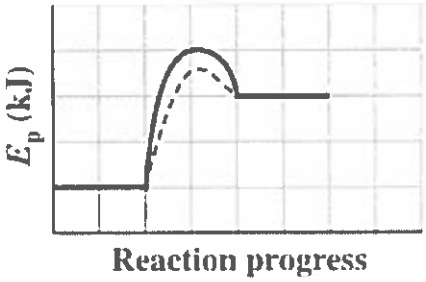
$$2\,C_2H_2(g) + 3\,H_2(g) \rightarrow C_2H_4(g) + C_2H_6(g) + 486.4\ kJ$$

34. Which of the following energy diagrams represents the energy changes for both the catalyzed and uncatalyzed reactions?

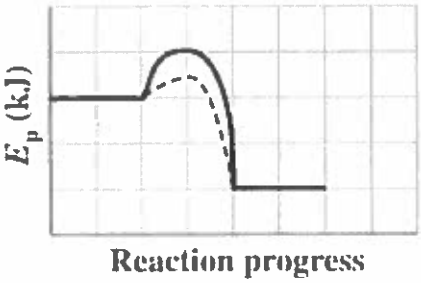
A.



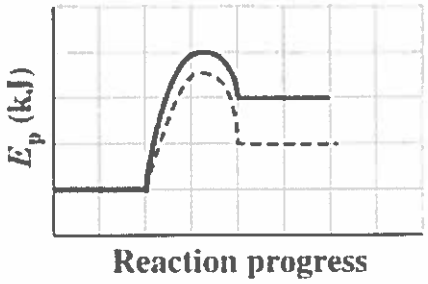
B.



C.



D.



– – – – – Catalyzed

——— Uncatalyzed