Ch 5 Thermochemistry

1. A system has an increase in internal energy, ΔE, of 40 kJ. If 20 kJ of work, w, is done on the system, what is the heat change, q?
   a) +60 kJ
   b) +40 kJ
   c) +20 kJ
   d) -20 kJ
   e) -60 kJ

2. A gas at 20 atm pressure with a volume of 2.0 Liters expands against a 5 atm pressure to a volume of 8.0 Liters. How much work is done by the gas?
   a) 30 L·atm
   b) 18 L·atm
   c) 8 L·atm
   d) 5 L·atm

3. Which equation represents the heat of formation, ΔH_f, for $MgCl_{2(s)}$?
   a) $Mg^{+2}_{(aq)} + 2\ Cl^{-1}_{(aq)} \rightarrow MgCl_{2(s)}$
   b) $Mg_{(s)} + 2\ Cl_{(g)} \rightarrow MgCl_{2(s)}$
   c) $MgCl_{2(s)} \rightarrow Mg^{+2}_{(aq)} + 2\ Cl^{-1}_{(aq)}$
   d) $Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$

4. Take a balloon or rubberband. Quickly stretch the balloon or rubberband and *quickly* press it against your lower lip. What is the **ΔH** for the reaction:

   unstretched → stretched

   a) +
   b) 0
   c) –
   d) impossible to tell

5. Which of the following is NOT a state function?
   a) work
   b) enthalpy
   c) energy
   d) none of these

6. The correct units for specific heat capacity:
   a) J/°C
   b) J/g
   c) J/g °C
   d) °C/g

7. How much heat is required to convert solid sulfur to gaseous sulfur at 298 K and 1 atm pressure?

	ΔH° (kJ/mol)
$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$	–395
$S_{(g)} + O_{2(g)} \rightarrow SO_{2(g)}$	–618

   a) –1013 kJ/mol
   b) –223 kJ/mol
   c) +223 kJ/mol
   d) +618 kJ/mol

8. Using the $\Delta H_f°$ given below, calculate the $\Delta H_{combustion}$ for propane, C_3H_8.

	$\Delta H_f°$ (kJ/mol)
$H_2O_{(L)}$	-286
$CO_{2(g)}$	-394
$C_3H_{8(g)}$	-104

   a) 576 kJ
   b) -576 kJ
   c) -2222 kJ
   d) -2330 kJ

9. The heat of vaporization of methane, CH_4, at its boiling point is 9.20 kJ/mol. How much heat energy is required to vaporize 100. g of methane at its boiling point?
   a) 1380 kJ
   b) 86.3 kJ
   c) 21.6 kJ
   d) 57.4 kJ

10. How much energy is required to melt 10.0 g benzene, C_6H_6? The heat of fusion of benzene is 2.37 kJ/mol.
   a) 3.30 kJ
   b) 23.7 kJ
   c) 1850 kJ
   d) 0.303 kJ

11. If ΔH for a reaction is positive, …
   a) the reaction rate is generally very fast.
   b) the enthalpy change of the reverse reaction is positive.
   c) the enthalpy of the products is greater than the enthalpy of the reactants.
   d) the energy released during bond formation is greater than the energy absorbed during bonding breaking for the reaction.

12. Given the two equations:

$2\ S_{(s)} + 3O_{2(g)} \rightarrow 2\ SO_{3(g)}$ $\Delta H° = -790.4$ kJ

$SO_{2(g)} + {}^{1}/_{2}O_{2(g)} \rightarrow SO_{3(g)}$ $\Delta H° = -99.1$ kJ

What is the standard enthalpy of formation for sulfur dioxide, SO_2(g)?

a) +99.1 kJ c) –592.2 kJ

b) –296.1 kJ d) –839.5 kJ

13. When 0.100 g benzoic acid ($HC_6H_4CO_2$) and excess oxygen is ignited in a bomb calorimeter, the temperature of the water changes from 25.000°C to 25.225°C. The heat capacity of the calorimeter is 603 J/°C. What is the ΔE for this reaction?

a) -597 J c) -136 J

b) -1660 J d) -149 J

14. Under conditions of constant volume, the heat change that occurs during a chemical reaction is equal to

a) ΔH c) ΔT

b) ΔE d) ΔP

15.

$$C_2H_{2(g)} + 2\ H_{2(g)} \rightarrow C_2H_{6(g)}$$

Information about the substances involved in the reaction represented above is summarized in the following tables.

Substance	$\Delta H°_f$ (kJ/mol)
$C_2H_{2(g)}$	226.7
$C_2H_{6(g)}$	-84.7

(a) Write the equation for the heat of formation of $C_2H_{6(g)}$

(b) Use the above information to determine the enthalpy of reaction for the equation given.

16.

$$C_6H_5OH_{(s)} + 7\ O_{2(g)} \rightarrow 6\ CO_{2(g)} + 3\ H_2O_{(l)}$$

When a 2.000-gram sample of pure phenol, $C_6H_5OH_{(s)}$, is completely burned according to the equation above, 64.98 kilojoules of heat is released. Use the information in the table below to answer the questions that follow.

Substance	Standard Heat of Formation, $\Delta H°_f$, at 25°C (kJ/mol)
$CO_{2(g)}$	-393.5
$H_2O_{(l)}$	-285.85
$C_6H_5OH_{(s)}$	?

(a) Calculate the **molar** heat of combustion of phenol in kilojoules per mole at 25°C.

(b) Calculate the standard heat of formation, $\Delta H°_f$, of phenol in kilojoules per mole at 25°C.

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Answers:

1.	C	6.	C	11.	C
2.	A	7.	C	12.	B
3.	D	8.	C	13.	C
4.	C	9.	D	14.	B
5.	A	10.	D		

Notes:

1. an increase in internal energy means an increase in P.E. of system by 40 kJ
   work done ON system increases P.E., +20 kJ, so q = +20 kJ, too.
2. work = $P\Delta V$ = 5 atm x (8-2 L)… the 20 atm is not used for anything.
4. balloon gets warm, $\Delta H < 0$
5. each of these only depends on the STATE of the substance, not on its HISTORY.
7. reverse second reaction
8. recall: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ and use Hess's Law
9. Given: 100g CH_4, use molar mass & H_{vap} as conversion factors.
10. Given: 10.0g C_6H_6, use molar mass & H_{fus} as conversion factors.
11. this is an "uphill" reaction.
12. take half of first equation, reverse second equation. if you reverse and double second equation, you get TWICE the answer.
13. answer = heat capacity x ΔT… you don't use 0.100 g anywhere. You would IF the question asked for MOLAR heat of combustion.
14. if volume is constant, $P\Delta V$ work = 0 so $\Delta E = q + w$ becomes $\Delta E = q$.
15. answers will be reviewed in class
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