Name:_____ SUPA Chem **Ch5 Problems**

5.1+2 Nature of energy and first law

1) The internal energy of a system _____.
   A) is the sum of the kinetic energy of all of its parts
   B) is the total of the potential and kinetic energies of the components
   C) is the sum of the vibrational, rotational and translational energies of all of its components
   D) is the sum of the energies of the nuclei of the atoms of all of the molecules
   E) none of the above

2) Which of the following conditions will always result in an increase of the internal energy of a system?
   A) Heat is lost and work is done on the surroundings
   B) Heat is absorbed by the system and it does work on the surroundings
   C) Heat is lost and work is done on the system by the surroundings
   D)Heat is absorbed by the system and it has work on on it by the surroundings
   E) None of the above is correct.

3) At what velocity (m/s) must a 20.0 g object be moving in order to possess a kinetic energy of 1.00 J?

4) How much energy does a 100-watt electric incandescent light bulb consume if left on for 24 hours? [1 Watt (W) = 1 J/sec]

5) Which is/are state function(s)?
   A) w
   B) H
   C) heat
   D) q
   E) none of the above

6) What is the ΔE of a system that absorbs 24.4 J of heat and does 6.2 J of work on the surroundings?

7) What is the change in the internal energy of a system that absorbs 4200 J of heat and that does 8954 J of work on the surroundings?

5.3+4 Enthalpy and enthalpies of reaction

8) Explain what the sign of ΔH is for endothermic and exothermic reactions.

9) Which of the following statements is/are false?

i) Internal energy is a state function.
ii) Enthalpy is an intensive property.
iii) The enthalpy change for a reaction is equal in magnitude, but opposite in sign, to the enthalpy change for the reverse reaction.
iv) The enthalpy change for a reaction depends on the state of the reactants and products.
v) The enthalpy of a reaction is equal to the heat of the reaction.

a) i, ii
b) ii
c) iv
d) i, iii
e) iii

10) The following reaction can be described as

$$N_2(g) + 2O_2(g) \rightarrow 2NO_2 \qquad \Delta H = +182.6 \text{ kJ}$$

A) endothermic with energy being released
B) endothermic with energy being absorbed
C) exothermic with energy being released
D) exothermic with energy being absorbed
E) thermoneutral with energy neither released nor absorbed

11) A negative ΔH corresponds to an _____ process.

12) ΔH for an endothermic process is _____ and the ΔH for an exothermic process is _____.

13) The value of ΔH° for the following reaction is -790 kJ. What is the enthalpy change when 2.6 grams of S reacts?

$$2S\,(s) + 3O_2\,(g) \rightarrow 2SO_3\,(g)$$

14) The value of ΔH° for the following reaction is -6535 kJ. How much energy is released when 32.00 g of C_6H_6 (l) combusts?

$$2\ C_6H_6\ (l)\ +\ 15\ O_2\ (g)\ \rightarrow\ 12\ CO_2\ (g)\ +\ 6\ H_2O\ (l)$$

15) Hydrogen peroxide decomposes into water and oxygen at constant pressure, represented by the reaction:

$$2\ H_2O_2\ (l)\ \rightarrow\ 2\ H_2O\ (l) + O_2\ (g) \qquad \triangle H = -196.0\ kJ$$

Calculate q when 12.50 g of hydrogen peroxide decomposes.

16) The ΔH° for the following reaction is -482 kJ. How much heat is released to the surroundings when 13.45 g of CO (g) completely combusts?

$$2\ CO\ (g)\ +\ O_2\ (g)\ \rightarrow\ 2\ CO_2\ (g)$$

5.5 Calorimetry

17) What are the units of heat capacity?

18) What are the units for specific heat?

19) How many joules of heat are needed to be absorbed to increase a 14.68 g sample of calcium carbonate [$CaCO_3$ (s)] from 26.3 °C to 36.8 °C. (specific heat of calcium carbonate is 0.82 J/g-K)

20) What is the final temperature of a 125 gram sample of calcium carbonate that absorbed 67.8 J of heat at 22.5°C? (specific heat of calcium carbonate is 0.82 J/g-K)

21) The addition of 47.6 J of energy to a sample of calcium carbonate raises the temperature 1.08 °C. What is the mass of calcium carbonate sample? (specific heat of calcium carbonate is 0.82 J/g-K)

22) The density of liquid bromine is 3.12 g/mL and it has a specific heat of 0.226 J/g-K. How much heat is needed to raise the temperature of 8.00 mL of bromine from 26.00 °C to 27.80 °C?

23) The combustion of titanium produces titanium dioxide:

$$Ti\ (s) + O_2\ (g) \rightarrow TiO_2\ (s)$$

When 4.081 g of titanium is combusted in a bomb calorimeter (heat capacity of 9.84 kJ/K), the temperature of the calorimeter increases from 24.70 °C to 98.60 °C. What is the molar heat of combustion for titanium by this reaction?

5.6 Hess's law

24)Summarize Hess's law

25)What is the ΔH for the reaction

$$IF_5\ (g) \rightarrow IF_3\ (g) + F_2\ (g)$$

If given:

$IF\ (g) + F_2\ (g) \rightarrow IF_3\ (g)$ $\Delta H = -390$ kJ

$IF\ (g) + 2\ F_2\ (g) \rightarrow IF_5\ (g)$ $\Delta H = -745$ kJ

26) Given the following;

$N_2\ (g) + 2\ O_2\ (g) \rightarrow 2NO_2\ (g)$ $\Delta H = 66.4$ kJ

$2NO\ (g) + O_2\ (g) \rightarrow 2NO_2\ (g)$ $\Delta H = -114.2$ kJ

What is the enthalpy of the reaction for the following reaction?

$$N_2\ (g) + O_2\ (g) \rightarrow 2NO\ (g)$$

27) Given the following:

$2S\ (s) + 3O_2\ (g) \rightarrow 2SO_3\ (g)$ $\Delta H = -790$ kJ

$S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$ $\Delta H = -297$ kJ

What is the enthalpy of the following reaction?

$2SO_2\ (g) + O_2\ (g) \rightarrow 2SO_3\ (g)$

28) What is the enthalpy change for the following reaction

$4NO\ (g) \rightarrow 2NO_2\ (g) + N_2\ (g)$

Given the following information

$N_2\ (g) + O_2\ (g) \rightarrow 2NO\ (g)$ $\Delta H = +180.7$ kJ

$2NO\ (g) + O_2\ (g) \rightarrow 2N\ O_2\ (g)$ $\Delta H = -113.1$ kJ

5.7 Enthalpies of formation

29) Which of the following reactions is the $\Delta H°_{rxn}$ equal to the heat of formation of the product? (there may be multiple)

i) $C(s) + 4H\ (g) \rightarrow CH_4(g)$

ii) $(1/2)\ N_2\ (g) + O_2\ (g) \rightarrow NO_2\ (g)$

iii) $C\ (s) + O_2(g) \rightarrow CO_2\ (g)$

iv) $12C\ (g) + 11H_2\ (g) + 11O\ (g) \rightarrow C_6H_{22}O_{11}\ (g)$

30) $\Delta H_f°$ is <u>not</u> zero for _____.

A) Hg(g)
B) Cl_2 (g)
C) S_8 (s)
D) Ca (s)
E) Br_2 (l)

31) Given the information in the data table, what is the $\Delta H°_{rxn}$ for the reaction?

$4NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4NO\ (g) + 6\ H_2O\ (l)$

Substance	$\Delta H_f°$ (kJ/mol)
H_2O (l)	-286
NO (g)	90
NO_2 (g)	34
HNO_3 (aq)	-207
NH_3 (g)	-46

32) Given the information in the data table, what is the $\Delta H°_{rxn}$ for the reaction

$C_2H_5OH\ (l) + O_2\ (g) \rightarrow CH_3CO_2H\ (l) + H_2O\ (l)$

Substance	$\Delta H_f°$ (kJ/mol)
C_2H_4 (g)	52.3
C_2H_5OH (l)	-277.7
CH_3CO_2H (l)	-484.5
H_2O (l)	-285.8

33) Given the information in the data table, what is the $\Delta H°_{rxn}$ for the following reaction?

$3NO_2\ (g) + H_2O\ (l) \rightarrow 2HNO_3\ (aq) + NO\ (g)$

Substance	$\Delta H_f°$ (kJ/mol)
H_2O (l)	-286
NO (g)	90
NO_2 (g)	34
HNO_3 (aq)	-207
NH_3 (g)	-46

34) Given the information in the data table, what is the $\Delta H°_{rxn}$ for the following reaction?

$IF_5\,(g) + F_2\,(g) \rightarrow IF_7\,(g)$

Substance	$\Delta H_f°$ (kJ/mol)
IF (g)	-95
IF_5 (g)	-840
IF_7 (g)	-941

CH5 answers

1. B
2. D
3. 10 m/s
4. 8.64×10^6
5. B only
6. +18.2 J
7. -4754 J
8. Endothermic reactions have a +ΔH as heat is being absorbed and exothermic reactions have a -ΔH as energy is being given off or lost to the surroundings.
9. B
10. B
11. exothermic
12. Positive, negative
13. -32.0 kJ
14. 1338 kJ
15. -36.01 kJ
16. 116 kJ
17. J/K or J/°C
18. C) J/g-K or J/g-°C
19. 130 J
20. 23.2 °C
21. 53.7 g
22. 10.2 J
23. -8530 kJ/mol
24. The heat of any reaction (ΔH) is equal to the sum of the heats of reaction for any set of reactions where the sum of those reactions is equivalent to the overall reaction. If you have a set of 'steps' and know the ΔH for each of those steps, and together those steps give you an overall reaction, you can add the ΔH of the steps to give you the ΔH of the overall reaction.
25. +355 kJ
26. 180.6 kJ
27. -196 kJ
28. -293.8 kJ
29. ii and iii
30. A
31. -1172 kJ
32. -492.6 kJ
33. -140 kJ
34. -101 kJ