Chapter 5

Hess's Law

Materials to use to study for Exam 4:

1. End of Chapter 5 problems: 2,7,10, 18,19,20,27 (more gas = more expansion)33,37,39,43,47,49,51,53,55,57,61,65,67,69,71,73,75,77,78,81,83,85,87,89,92,93,94,
2. Smartwork5, Chapter 5
3. Energy, q, work, phase changes Lecture notes and clicker questions
4. Energy, q, cold drinks, Hot Copper, cold water Lecture notes and clicker questions
5. Whiteboard lesson: How much ice is needed?
6. Practice Exam
7. End of Chapter 6 problems: 2,3,4,5,13,15,16,17,18,31,43,47,57,67,73,77,78,99,100,103,105,115,121,131
8. Smartwork5, Chapter 6

Energy units:

Which statement A–D about energy units is *not* correct?

a. The SI unit of energy is the Joule (J).

b. In terms of SI base units, 1 J = 1 kg m^2 s^{-2}.

c. A nutritional calorie (1 Cal) is 4.184 kJ.

d. A nutritional calorie (1 Cal) is equal to 1,000 cal.

e. Statements A–D all are correct.

Joule

The SI unit for Energy

$1\ J = 1\ kg\ m^2\ s^{-2}$

$1\ J = 1 kgm^2/s^2$

calories

A calorie is the energy required to raise one gram of water one degree Celcius.

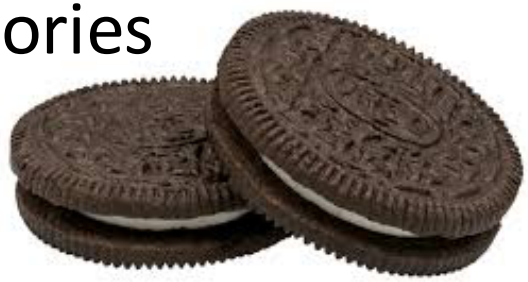
1 calorie = 4.184 J

Dietary Calories:

1 Calorie of diet pepsi = 1 kcal = 1000 calories

100 Calories of Oreos = 100 kcal = 1×10^5 calories

1 kcal = 4.184kJ



Which statement A–D about energy units is correct?

a. The SI unit of energy is the kilojoule (kJ).

b. In terms of SI base units, 1 J = 1 kg m^2 s^2.

c. A nutritional calorie (1 Cal) is 4.184 kJ.

d. A nutritional calorie (1 Cal) is equal to 100 cal.

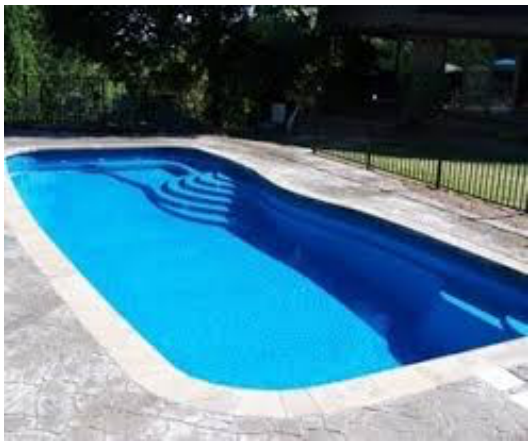
e. Statements A–D all are correct.

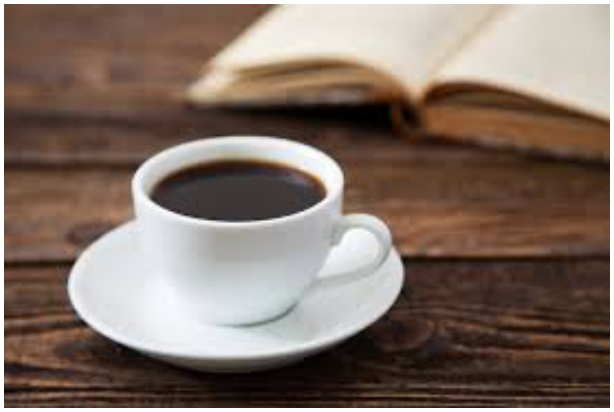
What has the higher enthapy content?

A. A swimming pool 375m^3 at 27°C

B. A cup of coffee (237 mL) at 80°C

C. They are the same.





What has the higher enthapy content?

A. A swimming pool 375m^3 at 27°C

B. A cup of coffee (237 mL) at 80°C

C. They are the same.

$\Delta H = mass \times Cs \times \Delta T$

$375 m^3 \times \frac{1000 L}{m^3} \times \frac{1000 mL}{L} \times \frac{1 g}{mL} \times 4.184 \frac{J}{g°C} \times (27°C - 25°C) = 3.13 \times 10^9 J$

$237 mL \times \times \frac{1 g}{mL} \times 4.184 \frac{J}{g°C} \times (80°C - 25°C) = 5.45 \times 10^4 J$

Hess's Law: add up reactions, add up enthalpy

ΔH^o_f is the energy gained or lost when a compound or molecule is formed from the elements in their natural state.

Calculate ΔH^o_f for SO_3 in kJ/mol given the following data:

Need: $S(s) + 1.5*O_2(g) \rightarrow SO_3(g)$ *Can have fractions of molecules

Have:

$S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta H^o = -296.8$ kJ

$SO_2(g) + ½\ O_2(g) \rightarrow SO_3(g)$ $\Delta H^o = -98.9$ kJ

Adding these:

$S(s) + O_2(g) + SO_2(g) + ½\ O_2(g) \rightarrow SO_2(g) + SO_3(g)$ $\Delta H^o = -395.7$kJ

Cancel out if on both sides, add up common molecules:

$S(s) + 1.5*O_2(g) \rightarrow SO_3(g)$ $\Delta H^o = -395.7$kJ

Use the following information to determine the standard enthalpy change when 1 mol of PbO(*s*) is formed from lead metal and oxygen gas:

$$Pb(s) + \frac{1}{2}O_2(g) \rightarrow PbO(s)$$

$$PbO(s) + C(\text{graphite}) \rightarrow Pb(s) + CO(g) \quad \Delta H^o = 107 \text{ kJ}$$

$$2C(\text{graphite}) + O_2(g) \rightarrow 2CO(g) \quad \Delta H^o = -222 \text{ kJ}$$

Need: $Pb(s) + \frac{1}{2}O_2(g) \rightarrow PbO(s)$

Have:

$PbO(s) + C(\text{graphite}) \rightarrow Pb(s) + CO(g)$ $\Delta H^o = 107$ kJ

$2C(\text{graphite}) + O_2(g) \rightarrow 2CO(g)$ $\Delta H^o = -222$ kJ

$Pb(s) + CO(g) \rightarrow PbO(s) + C(\text{graphite})$ $\Delta H^o = -107$ kJ

$C(\text{graphite}) + \frac{1}{2}O_2(g) \rightarrow CO(g)$ $\Delta H^o = -111$ kJ

$\Delta H^o = -218$kJ

Determine the change in enthalpy for the following reaction from the enthalpies of formation for the reactants and products. (ΔH_f for pure elements is zero.)

$$Cl_2(g) + C_2H_2Cl_2(g) \rightarrow C_2H_2Cl_4(g)$$

$C_2H_2Cl_2$, $\Delta H_f = 4.27$ kJ/mol

$C_2H_2Cl_4$, $\Delta H_f = -155.6$ kJ/mol

Add up ΔH^o_f for reactants

Add up ΔH^o_f for products

Products – Reactants = ΔH^o_{rxn}

(rxn = reaction)

Determine the change in enthalpy for the following reaction from the enthalpies of formation for the reactants and products. (ΔH_f for pure elements is zero.)

$$Cl_2(g) + C_2H_2Cl_2(g) \rightarrow C_2H_2Cl_4(g)$$

$C_2H_2Cl_2$, $\Delta H_f = 4.27$ kJ/mol

$C_2H_2Cl_4$, $\Delta H_f = -155.6$ kJ/mol

Products = -155.6= -155.6kJ

Reactants = 0 + 4.27kJ

Products-Reactants = -155.6 - 4.27= -160kJ

Given the standard heats of formation in the table below, what is ΔH^o for the following reaction:

$3\ N_2O_4(g) + 2\ H_2O(l) \rightarrow 4\ HNO_3(aq) + 2\ NO(g)$

Compound	$N_2O_4(g)$	$H_2O(l)$	$HNO_3(aq)$	$NO(g)$
ΔH^o_f *(kJ/mol)*	+11.1	–285.8	–207.4	+91.3

-108.7kJ