

- Radiant energy is
 - the energy stored within the structural units of chemical substances.
 - the energy associated with the random motion of atoms and molecules.
 - solar energy, i.e. energy that comes from the sun.
 - energy available by virtue of an object's position.
- Thermal energy is
 - the energy stored within the structural units of chemical substances.
 - the energy associated with the random motion of atoms and molecules.
 - solar energy, i.e. energy that comes from the sun.
 - energy available by virtue of an object's position.
- Chemical energy is
 - the energy stored within the structural units of chemical substances.
 - the energy associated with the random motion of atoms and molecules.
 - solar energy, i.e. energy that comes from the sun.
 - energy available by virtue of an object's position.
- Potential energy is
 - the energy stored within the structural units of chemical substances.
 - the energy associated with the random motion of atoms and molecules.
 - solar energy, i.e. energy that comes from the sun.
 - energy available by virtue of an object's position.
- Heat is
 - a measure of temperature.
 - a measure of the change in temperature.
 - a measure of thermal energy.
 - a measure of thermal energy transferred between two bodies at different temperature.
- An endothermic reaction causes the surroundings to
 - warm up.
 - become acidic.
 - condense.
 - decrease in temperature.
 - release CO₂.
- An exothermic reaction causes the surroundings to
 - warm up.
 - become acidic.
 - release CO₂.
 - decrease its temperature.
 - expand.
- A sample of nitrogen gas expands in volume from 1.6 L to 5.4 L at constant temperature. Calculate the work done in joules if the gas expands (a) against a vacuum, (b) against a constant pressure of 0.80 atm, and (c) against a constant pressure of 3.7 atm. $W = -P\Delta V$

Answer

$$a) P=0 \quad W = -P\Delta V = -0(\Delta V) = 0$$

$$b) P=0.8 \text{ atm} \quad W = -P\Delta V$$

$$W = -0.8 \times 1.013 \times 10^5 \times 3.8 \times 10^{-3}$$

$$W = -307 \text{ J} = -3 \times 10^2 \text{ J}$$

$$c) P=3.7 \quad W = -P\Delta V = -3.7 \times 1.013 \times 10^5 \times 3.8 \times 10^{-3} = -1.4 \times 10^3 \text{ J}$$

$$\Delta V = 5.4 - 1.6$$

$$= 3.8 \times 10^{-3} \text{ m}^3$$

$$P = 0.8 \times 1.013 \times 10^5$$

$$P = 3.7 \times 1.013 \times 10^5$$

9. The work done to compress a gas is 74 J. As a result, 26 J of heat is given off to the surroundings. Calculate the change in energy of the gas.

$$W = 74 \quad q_v = -26$$

$$\Delta E = q_v + W = -26 + 74 = 48 \text{ J}$$

10. Determine the amount of heat (in kJ) given off when $1.26 \times 10^4 \text{ g}$ of NO_2 are produced according to the equation: $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{NO}_2(\text{g}) \quad \Delta H = -114.6 \text{ kJ/mol}$



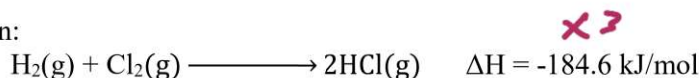
$$n = \frac{m}{M_w} = \frac{1.26 \times 10^4}{46} = 273.9$$

$$\text{② حساب عدد المولات} \\ (M_w = 14 + 2 \times 16) \\ 46$$

③ حساب كمية لطاقة نوزب عدد المولات بد حجم لطاقة المتأبئة للمول الواحد

$$57.3 \times 273.9 = 1.57 \times 10^4 \text{ kJ}$$

11. Consider the reaction:



If 3 moles of H_2 react with 3 moles of Cl_2 to form HCl , calculate the work done against a pressure of 1.0 atm at 25°C. What is ΔE for this reaction? Assume the reaction goes to completion.

Solution:

$$\Delta H = -184.6 \times 3 = -553.8 \text{ kJ/mol}$$

$$\Delta E = \Delta H + P\Delta V$$

zero

تصديرتي الحجم
لان عدد المولات ثابت
اذن الحجم ايضا ثابت

$$\Delta V = 0$$

$$\Delta E = \Delta H \\ = -553.8 \text{ kJ}$$

12. Consider two metals A and B, each having a mass of 100 g and an initial temperature of 20°C. The specific heat of A is larger than that of B. Under the same heating conditions, which metal would take longer to reach a temperature of 21°C?

Solution:

A takes longer time to reach 21 because it has higher (c)

13. A piece of silver of mass 362 g has a heat capacity of 85.7 J/°C. What is the specific heat of silver?

Solution:

$$s = \frac{C}{m} = \frac{85.7}{362} = 0.237 \text{ J/C.g}$$

14. A 0.1375-g sample of solid magnesium is burned in a constant-volume bomb calorimeter that has a heat capacity of 3024 J/°C. The temperature increases by 1.126°C. Calculate the heat given off by the burning Mg, in kJ/g and in kJ/mol.

Solution:

$$m = 0.1375 \text{ g}$$

$$\Delta t = 1.126 \text{ }^\circ\text{C}$$

$$1 \text{ mol (Mg)} = 24.3 \text{ g}$$

$$C = 3024 \text{ J/}^\circ\text{C}$$



$$q = C \Delta t = 3024 \times 1.126 = 3405 \text{ J} = 3.405 \text{ kJ}$$

$$q \text{ (kJ/g)} = \frac{3.405}{0.1375} = 24.76 \text{ kJ/g}$$

$$q \text{ (kJ/mol)} = 24.76 \times 24.3 = 601 \text{ kJ/mol}$$

15. Which is the more negative quantity at 25°C: ΔH_f° for $\text{H}_2\text{O}(l)$ or ΔH_f° for $\text{H}_2\text{O}(g)$?

Solution:

$\text{H}_2\text{O}(l)$ is more stable

$\Delta H_f^\circ (\text{H}_2\text{O}(l))$ more negative

16. Suggest ways (with appropriate equations) that would enable you to measure the ΔH_f° values of $\text{Ag}_2\text{O}(\text{s})$ and $\text{CaCl}_2(\text{s})$ from their elements. No calculations are necessary.



$$\Delta H_{\text{rxn}} = \Delta H_f^\circ(\text{Ag}_2\text{O})$$



$$\Delta H_{\text{rxn}} = \Delta H_f^\circ(\text{CaCl}_2)$$

17. Calculate the heat of decomposition for this process at constant pressure and 25°C:



(Look up the standard enthalpy of formation of the reactant and products in Table)

Solution:

$$\begin{aligned} \Delta H_{\text{rxn}} &= [\Delta H_f^\circ(\text{CaO}) + \Delta H_f^\circ(\text{CO}_2)] - \Delta H_f^\circ(\text{CaCO}_3) \\ &= [-635.1 - 393.5] - -1206.9 \\ &= 178 \text{ kJ/mol} \end{aligned}$$

Table 3.10.1: Some Standard Enthalpies of Formation at 25°C.

Compound	$\Delta H_f^\circ/\text{kJ mol}^{-1}$	$\Delta H_f^\circ/\text{kcal mol}^{-1}$	Compound	$\Delta H_f^\circ/\text{kJ mol}^{-1}$	$\Delta H_f^\circ/\text{kcal mol}^{-1}$
AgCl(s)	-127.068	-30.35	H ₂ O(g)	-241.818	-57.79
AgN ₃ (s)	+620.6	+148.3	H ₂ O(l)	-285.8	-68.3
Ag ₂ O(s)	-31.0	-7.41	H ₂ O ₂ (l)	-187.78	-44.86
Al ₂ O ₃ (s)	-1675.7	-400.40	H ₂ S(g)	-20.63	-4.93
Br ₂ (l)	0.0	0.00	HgO(s)	-90.83	-21.70
Br ₂ (g)	+30.907	+7.385	I ₂ (s)	0.0	0.0
C(s), graphite	0.0	0.00	I ₂ (g)	+62.438	+14.92
C(s), diamond	+1.895	+0.453	KCl(s)	-436.747	-104.36
CH ₄ (g)	-74.81	-17.88	KBr(s)	-393.798	-94.097
CO(g)	-110.525	-26.41	MgO(s)	-601.7	-143.77
CO ₂ (g)	-393.509	-94.05	NH ₃ (g)	-46.11	-11.02
C ₂ H ₂ (g)	+226.73	+54.18	NO(g)	+90.25	+21.57
C ₂ H ₄ (g)	+52.26	+12.49	NO ₂ (g)	+33.18	+7.93
C ₂ H ₆ (g)	-84.68	-20.23	N ₂ O ₄ (g)	+9.16	+2.19
C ₆ H ₆ (l)	+49.03	+11.72	NF ₃ (g)	-124.7	-29.80
CaO(s)	-635.09	-151.75	NaBr(s)	-361.062	-86.28
CaCO ₃ (s)	-1206.92	-288.39	NaCl(s)	-411.153	-98.24
CuO(s)	-157.3	-37.59	O ₃ (g)	+142.7	+34.11
Fe ₂ O ₃ (s)	-824.2	-196.9	SO ₂ (g)	-296.83	-70.93
HBr(g)	-36.4	-8.70	SO ₃ (g)	-395.72	-94.56
HCl(g)	-92.307	-22.06	ZnO(s)	-348.28	-83.22
HI(g)	+26.48	+6.33			

18. The standard enthalpies of formation of ions in aqueous solutions are obtained by arbitrarily assigning a value of zero to H^+ ions; that is, $\Delta H_f^\circ [H^+(aq)] = 0$.

(a) For the following reaction:



calculate ΔH_f° for the Cl^- ions.

(b) Given that ΔH_f° for OH^- ions is -229.6 kJ/mol , calculate the enthalpy of neutralization when 1 mole of a strong monoprotic acid (such as HCl) is titrated by 1 mole of a strong base (such as KOH) at 25°C .

a)

$$\Delta H_{rxn} = \Delta H_f(H^+) + \Delta H_f(Cl^-) - \Delta H_f(HCl)$$

$$-74.9 = 0 + \Delta H_f(Cl^-) - (-92.3)$$

$$\Delta H_f(Cl^-) = -74.9 - 92.3$$

$$= -167.2 \text{ kJ/mol}$$

b)

$$H^+ + OH^- \longrightarrow H_2O$$

$$\Delta H_{rxn} = \Delta H_f(H_2O) - [\Delta H_f(OH^-) + \Delta H_f(H^+)]$$

$$\Delta H_{rxn} = -285.8 - [-229.6] = -56.2 \text{ kJ/mol}$$

19. The standard enthalpy change for the following reaction is 436.4 kJ/mol :



Calculate the standard enthalpy of formation of atomic hydrogen (H). $\Delta H_f(H)$

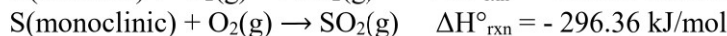
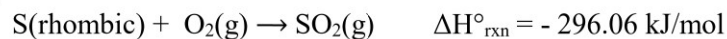
Solution:

$$\Delta H_{rxn} = 2\Delta H_f(H) - \Delta H_f(H_2) \xrightarrow{\text{zero}}$$

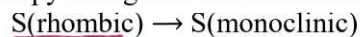
$$436.4 = 2\Delta H_f(H)$$

$$\Delta H_f(H) = \frac{436.4}{2} = 218.2 \text{ kJ/mol}$$

20. From these data,

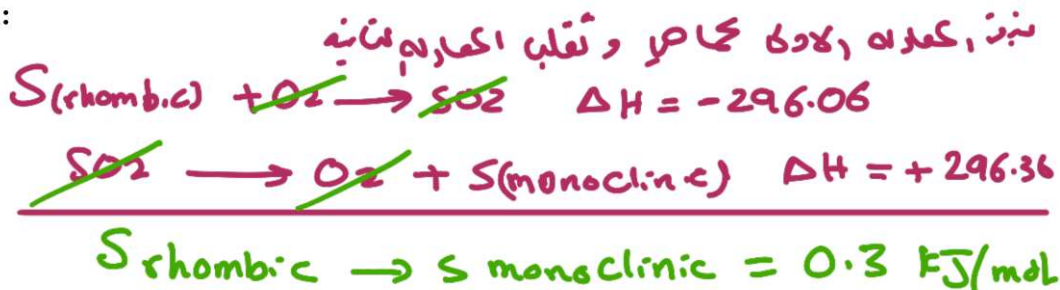


calculate the enthalpy change for the transformation

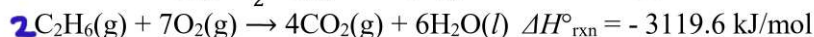
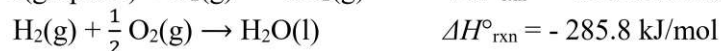
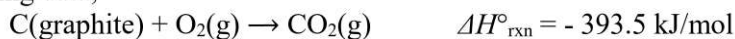


(Monoclinic and rhombic are different allotropic forms of elemental sulfur.)

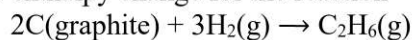
Solution:



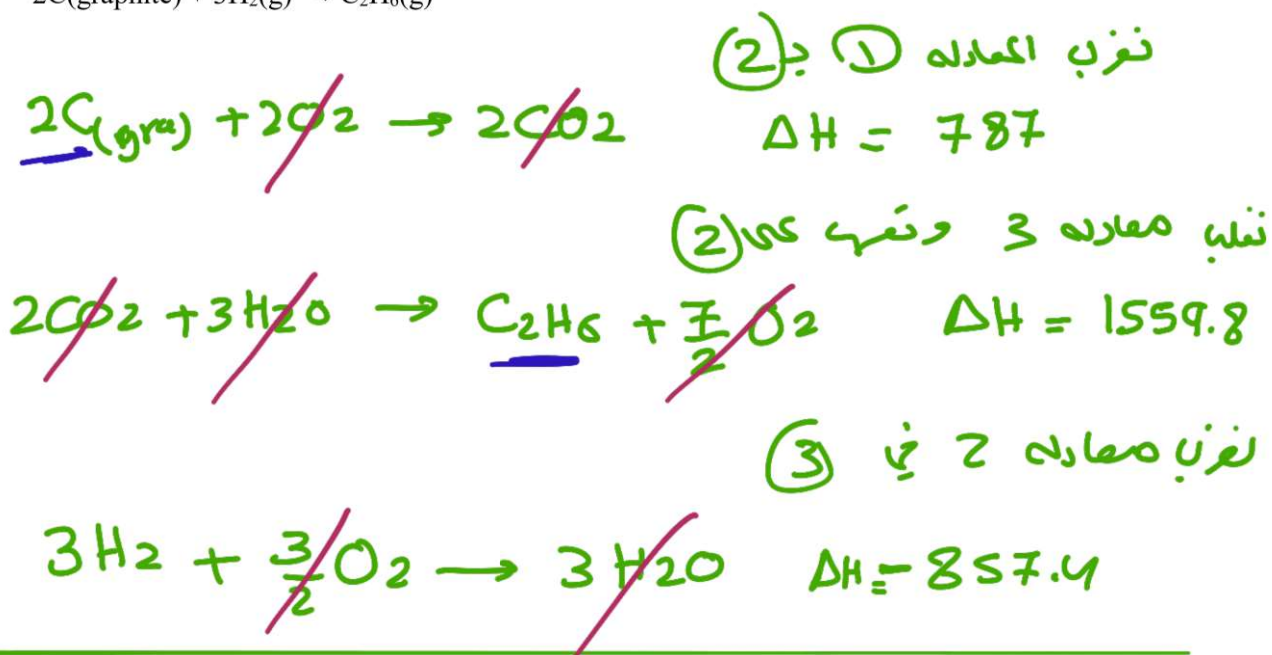
21. From the following data,



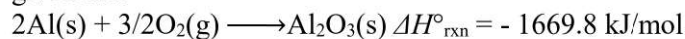
calculate the enthalpy change for the reaction



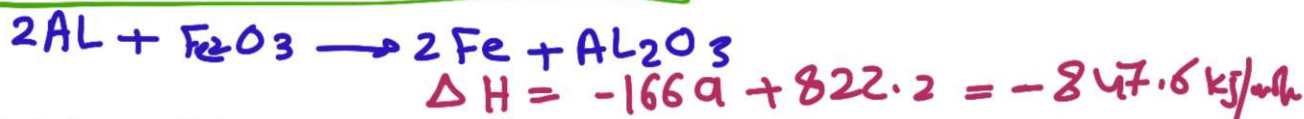
Solution:



22. Calculate the standard enthalpy change for the reaction $2\text{Al}(s) + \text{Fe}_2\text{O}_3(s) \rightarrow 2\text{Fe}(s) + \text{Al}_2\text{O}_3(s)$ given that



Solution:



23. Define *specific heat*.

Ans: The amount of heat required to raise the temperature of one gram of a substance by one degree Celsius.

$$q = m s \Delta T \quad \Delta T = \frac{q}{m s}$$

24. Mark the Answer with True or False

a) The specific heats of water and iron are 4.184 and 0.444 J/g°C, respectively. When equal masses of water and iron both absorb the same amount of heat, the temperature increase of the water will be 5.42 times greater than that of the iron.

$$\Delta T_w = \frac{q}{m s_w} \quad \Delta T_i = \frac{q}{m s_i}$$

Ans: ~~True~~ False

b) Chemical reactions in a bomb calorimeter occur at constant pressure.

$$\frac{\Delta T_w}{\Delta T_i} = \frac{s_i}{s_w} = \frac{0.444}{4.184}$$

Ans: True ✓

c) If $2\text{Mg}(s) + \text{O}_2(g) \rightarrow 2\text{MgO}(s)$, $\Delta H^\circ = -1203.6 \text{ kJ/mol}$.

For $\text{Mg}(s) + (1/2)\text{O}_2(g) \rightarrow \text{MgO}(s)$, the enthalpy change is $\Delta H = -601.8 \text{ kJ/mol}$.

$$0.106$$

Ans: True

d) The heat capacity of 20.0 g of water is 83.7 J/°C.

Ans: True

$$C = m s = 20 \times 4.184$$

e) The work done on the surroundings by the expansion of a gas is $w = -P\Delta V$.

Ans: True

f) The heat absorbed by a system at constant pressure is equal to $\Delta E + P\Delta V$.

Ans: True

g) In an endothermic process, heat is absorbed by the system.

Ans: True

h) A home aquarium is an example of an open system.

Ans: True

i) The heat of hydration (ΔH_{hydr}) of ions is always endothermic.

Ans: False