

CHAPTER 5

4.) $\Delta E = q + w$

Change in internal energy \downarrow
 Heat added to or liberated from a system \downarrow
 work done on or by a system \downarrow

- (a) (iii) is endothermic. Because q is (+)
 (b) ΔE is (+) in all!
 (c) All \rightarrow

- 7.) (a) $\Delta E = q + w$ w is (+) \rightarrow work done on system
 (b) pump gets warmer $\rightarrow q$ is (-) \rightarrow exothermic
 (c) Cannot determine sign of ΔE $\Delta E = (-) + (+)$ heat produced by the system

- 10.) (a) $N_2 + O_2 \rightarrow 2NO$
 w is 0 since no change in volume
 $w = -P\Delta V$
 \hookrightarrow pressure-volume work

- (b) $\Delta H_f = 90.37 \text{ kJ/mol}$
 \hookrightarrow when elements combine to form one mole of product

13.) (a) $E_{el} = \frac{kQ_1Q_2}{d}$ (Coulomb's Law)

$= \frac{(8.99 \times 10^9 \text{ Jm/C}^2) (-1.60 \times 10^{-19} \text{ C}) (1.60 \times 10^{-19} \text{ C})}{(53 \text{ pm}) (\frac{1 \text{ m}}{1 \times 10^{12} \text{ pm}})}$

$= -4.3 \times 10^{-18} \text{ J}$

(b) E_{el} at 1.0 nm = $-2.3 \times 10^{-19} \text{ J}$

$\Delta E_{el} = 4.1 \times 10^{-18} \text{ J}$ \leftarrow find difference between these

- (c) PE of system \uparrow s as distance between the oppositely-charged particles increases.

$$15.) a) F = k \frac{Q_1 Q_2}{d^2}$$

$$k = 8.99 \times 10^9 \text{ J}\cdot\text{m}/\text{C}^2$$

$$k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$$

J = Nm

$$= 8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2} \left(\frac{(-1.60 \times 10^{-19} \text{ C})(1.60 \times 10^{-19} \text{ C})}{\left((1.00 \times 10^2 \text{ pm}) \left(\frac{1 \text{ m}}{10^{12} \text{ pm}} \right) \right)^2} \right)$$

$$= -2.3 \times 10^{-8} \text{ N}$$

$$b) F = G \frac{m_1 m_2}{d^2}$$

$$G = 6.674 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$$

$$= 6.674 \times 10^{-11} \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2} \left(\frac{\overset{\text{electron}}{(9.10 \times 10^{-31} \text{ kg})(1.66 \times 10^{-27} \text{ kg})}}{\left((1.00 \times 10^2 \text{ pm}) \left(\frac{1 \text{ m}}{10^{12} \text{ pm}} \right) \right)^2} \right)$$

$$= 1.0 \times 10^{-47} \text{ N}$$

$$c) \frac{2.3 \times 10^{-8} \text{ N}}{1.0 \times 10^{-47} \text{ N}} =$$

electrostatic force is
 2.3×10^{39} X greater
than gravitational force

$$17.) E_{el} = k \frac{Q_1 Q_2}{d}$$

$$= 8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2} \left(\frac{(1.6 \times 10^{-19} \text{ e})(-1.6 \times 10^{-19} \text{ e})}{\left((0.50 \text{ nm}) \left(\frac{1 \text{ m}}{10^9 \text{ nm}} \right) \right)^2} \right)$$

$$E_{el} = -4.6 \times 10^{-19} \text{ J}$$

↖ attraction

- Work is the energy required to move an object against a force.
 - At infinite separation, the E_{el} of the pair of ions would be zero → electrostatic P.E.
 - The magnitude of the work required = the electrostatic PE of the pair of ions
- $$W = 4.6 \times 10^{-19} \text{ J}$$

- 19) a) Force \rightarrow gravitational force
 Work is done to oppose gravity $\&$ lift pencil a certain distance from table.
- b) Force \rightarrow spring force
 Work is done as coiled spring is opposed $\&$ compressed over a distance.

- 21) a) A **closed system** can exchange Energy with its environment in the form of heat or work. A closed system cannot exchange matter with the surroundings.
- b) An **isolated system** cannot exchange energy or matter with its surroundings.

23.) a.) Energy

b.) Internal Energy \rightarrow the sum of all the kinetic and potential energies of the components of a system.

c.) The internal energy of a closed system can change if

- 1) work is done by the system or on the system
- 2) heat is transferred to the system from the surroundings or from the system to the surroundings.

25.) a) $\Delta E = q + w$

$= .763 \text{ kJ} + (-.840 \text{ kJ})$

$= -.077 \text{ kJ}$

endo

internal E \downarrow

sys. does work on surroundings

b) $q = -66.1 \text{ kJ}$ (exo)

$w = +44.0 \text{ kJ}$ (work done on system)

$\Delta E = q + w$

$= -66.1 \text{ kJ} + 44.0 \text{ kJ}$

$= -22.1 \text{ kJ}$

E \downarrow

$$\bar{E} = q + w$$

27.) a) In case 2, no work is done on the surroundings, so the gas will absorb most of the energy as heat. Temperature increases.

b) Case 1 (movable piston) $\rightarrow -w, +q$
 \downarrow
work will be done on surroundings \rightarrow some energy will be absorbed as heat.

Case 2 (fixed piston) $\rightarrow w=0, +q$
 \downarrow
no work done on surroundings or system \rightarrow most of energy will be absorbed as heat

29.) A state function is a property of a system that is determined by specifying the system's condition or state (in terms of temp, press, etc.). The value of a state function depends only on the present state of the system, not the path the system took to reach that state.

ex: Energy

Carefully read 2nd ¶ on p. 172.

pressure-volume work

31.)

$$w = -P\Delta V$$

$$= -1.0 \text{ atm} (-50 \text{ L})$$

$$= -50 \text{ L}\cdot\text{atm}$$

$$= -51 \text{ J}$$

$$1 \text{ L}\cdot\text{atm} = 101.3 \text{ J}$$

$$14.) a) E_{el} = k \frac{Q_1 Q_2}{d} = \frac{8.99 \times 10^9 \text{ Jm/C}^2 (1.60 \times 10^{-19} \text{ C})^2}{62 \text{ pm} \left(\frac{1 \text{ m}}{10^{12} \text{ pm}} \right)}$$

$$= 3.7 \times 10^{-18} \text{ J}$$

↑ sign is (+) = repulsion

$$b) E_{el} \text{ at } 1.0 \text{ nm} = \frac{(8.99 \times 10^9 \text{ Jm/C}^2)(1.60 \times 10^{-19} \text{ C})^2}{1.0 \text{ nm} \left(\frac{1 \text{ m}}{10^9 \text{ nm}} \right)}$$

$$= 2.3 \times 10^{-19} \text{ J}$$

$$\Delta E_{el} = 3.47 \times 10^{-18} \text{ J}$$

c) PE of system ↓ as distance between the like-charged particles ↑.

$$26.) \Delta E = q + w$$

q is (-) → system loses heat

w is (+) → work done on system

$$(a) \Delta E = -.655 \text{ kJ} + .382 \text{ kJ} = \textcircled{-.273 \text{ kJ}}$$

(b) q is (+), w is 0

exothermic process

$$\Delta E = q + w$$

$$= \textcircled{+322 \text{ J}}$$

endothermic process

$$32.) w = -P\Delta V$$

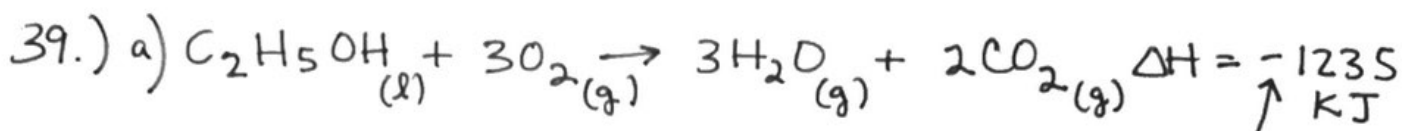
$$= -.857 \text{ atm}(1.26 \text{ L} - 5.00 \text{ L})$$

$$= 3.21 \text{ L}\cdot\text{atm}$$

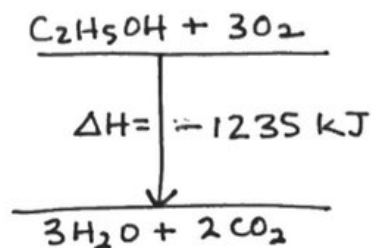
$$= 325 \text{ J}$$

$$\Delta V = V_f - V_i$$

$$1 \text{ L}\cdot\text{atm} = 101.3 \text{ J}$$



b) ΔH is (-) so energy is lost from the system.



↑
exothermic

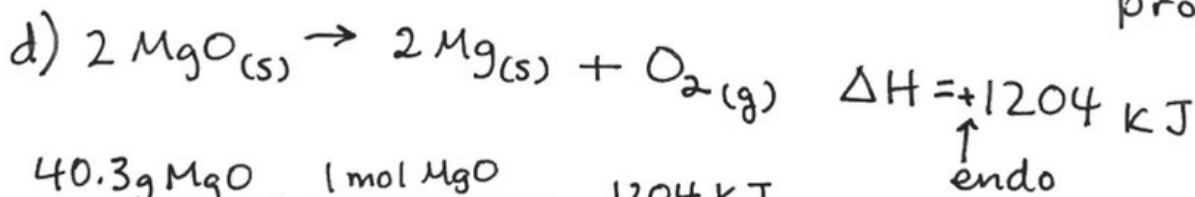
41.) a) $\Delta H = -284.6 \text{ KJ} / 2 \text{ mol } O_3 = -142.3 \text{ KJ} / \text{mol } O_3$

b) ΔH is (-), $2O_3$ has the higher enthalpy

43. a) Exothermic (ΔH is (-))

b) $\frac{3.55 \text{ g Mg}}{1} \times \frac{1 \text{ mol Mg}}{24.305 \text{ g Mg}} \times \frac{-1204 \text{ KJ}}{2 \text{ mol Mg}} = -87.9 \text{ KJ}$
of heat transferred

c) $\frac{-234 \text{ KJ}}{1} \times \frac{2 \text{ mol MgO}}{-1204 \text{ KJ}} \times \frac{40.30 \text{ g MgO}}{1 \text{ mol MgO}} = 15.7 \text{ g MgO}$
produced

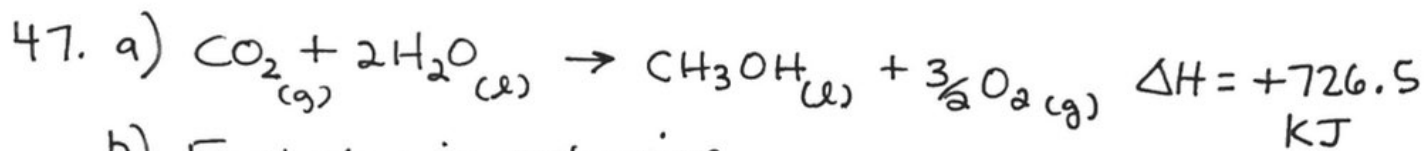


$\frac{40.3 \text{ g MgO}}{1} \times \frac{1 \text{ mol MgO}}{40.30 \text{ g MgO}} \times \frac{1204 \text{ KJ}}{2 \text{ mol MgO}} = +602 \text{ KJ}$ heat absorbed

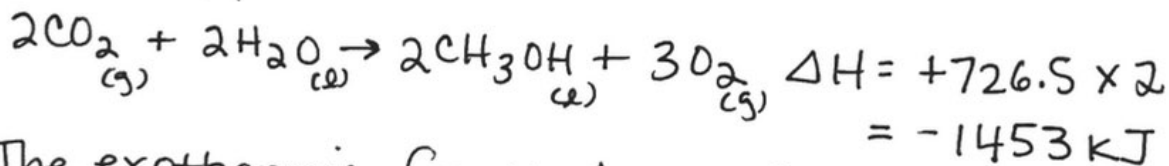
$$45. a) \frac{.450 \text{ mol AgCl}}{1} \times \frac{-65.5 \text{ kJ}}{1 \text{ mol AgCl}} = -29.5 \text{ kJ}$$

$$b) \frac{9.00 \text{ g AgCl}}{1} \times \frac{1 \text{ mol AgCl}}{143.3 \text{ g AgCl}} \times \frac{-65.5 \text{ kJ}}{1 \text{ mol AgCl}} = -4.11 \text{ kJ}$$

$$c) \frac{9.25 \times 10^{-4} \text{ mol AgCl}}{1} \times \frac{+65.5 \text{ kJ}}{1 \text{ mol AgCl}} = .0606 \text{ kJ} \\ = 60.6 \text{ J}$$



b) Enthalpy is extensive.



c) The exothermic forward reaction is more likely to be thermodynamically favored.

d) Decrease! Vaporization (l → g) is endothermic. If the product were $\text{H}_2\text{O}(g)$, the reaction would be more endothermic and would have a smaller negative ΔH .

P.E. 2) $C = .821 \frac{J}{gK}$

a) $m = 50.0 \text{ kg} = 5.00 \times 10^4 \text{ g}$
 $\Delta T = 12.0^\circ\text{C}$

$$Q = mc\Delta T$$
$$= (5.00 \times 10^4 \text{ g}) (.821 \frac{J}{g^\circ\text{C}}) (12.0^\circ\text{C})$$
$$= 492000 \text{ J}$$
$$= \boxed{490 \text{ kJ}}$$

b) $\Delta T = \frac{Q}{mc} = \frac{450,000 \text{ J}}{(5.00 \times 10^4 \text{ g}) (.821 \frac{J}{g^\circ\text{C}})} = 10.962$
 $\Delta T = \boxed{11.0^\circ\text{C}}$

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- 49) a) molar heat capacity $\frac{J}{\text{mol}^\circ\text{C}}$ or $\frac{J}{gK}$
b) specific heat $\frac{J}{g^\circ\text{C}}$ or $\frac{J}{gK}$
c) mass of pipe

50)

<u>A</u>	<u>B</u>
$\Delta T_{\text{H}_2\text{O}} = 10.0^\circ\text{C}$	$\Delta T_{\text{H}_2\text{O}} = 2.60^\circ\text{C}$
$T_i \text{ of } A = 100^\circ\text{C}$	$T_i \text{ of } B = 100^\circ\text{C}$
1000 mL H ₂ O	1000 mL H ₂ O

- a) A released more heat to the water.
A must have absorbed more heat to get to 100°C .
A has a greater heat capacity.
* The greater the heat capacity of an
* object, the greater the heat required to
* produce a given rise in temperature.
- b) Cannot compare specific heats of A and B because do not know their masses.

$$51) a) 4.184 \text{ J/g}^\circ\text{C} \text{ or } 4.184 \text{ J/gK}$$

$$b) \frac{4.184 \text{ J}}{1 \text{ g}^\circ\text{C}} \times \frac{18.02 \text{ g}}{1 \text{ mol}} = 75.40 \text{ J/mol}^\circ\text{C}$$

$$c) 185 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} = 774 \text{ J}^\circ\text{C}$$

$$d) q = mC\Delta T \\ = (1.000 \times 10^4 \text{ g}) (4.184 \text{ J/g}^\circ\text{C}) (46.2 - 24.6) \\ = 904000 \text{ J} \\ \boxed{904 \text{ kJ}}$$

$$52) a) q = mC\Delta T$$

Same Same

The greater the specific heat, the more heat is required to change temperature.

H_2 has the smallest specific heat so it will require the least amount of heat to change temperature.

$$b) q = (50.0 \text{ g}) (1.4 \text{ J/gK}) (10 \text{ K}) = \boxed{70 \text{ J}}$$

$$53) a) q = mC\Delta T \\ = (80.0 \text{ g}) (2.22 \text{ J/g}^\circ\text{C}) (25.0 - 10.0) \\ = 2664 \text{ J} \\ = \boxed{2.66 \text{ kJ}}$$

$$b) \text{C}_8\text{H}_{18} \Rightarrow \frac{2.22 \text{ J}}{1 \text{ g}^\circ\text{C}} \times \frac{114.26 \text{ g}}{1 \text{ mol}} = 254 \text{ J/mol}^\circ\text{C}$$

$$\text{H}_2\text{O} \Rightarrow \frac{4.184 \text{ J}}{1 \text{ g}^\circ\text{C}} \times \frac{18.02 \text{ g}}{1 \text{ mol}} = 75.40 \text{ J/mol}^\circ\text{C}$$

54.) a) $m = 100.0 \text{ g}$
 $T_i = 25.0^\circ\text{C}$
 $T_f = 50.0^\circ\text{C}$ } $\Delta T = 25.0^\circ\text{C}$
 $q = 322 \text{ J}$

$$q = mc\Delta T$$

$$C = \frac{q}{m\Delta T}$$

$$C = \frac{322 \text{ J}}{(100.0 \text{ g})(25.0^\circ\text{C})}$$

$$= \boxed{.129 \text{ J/g}^\circ\text{C}}$$

b) $C_{\text{Fe}} = .45 \text{ J/g}^\circ\text{C}$
 $C_{\text{Au}} = .129 \text{ J/g}^\circ\text{C}$ } For gold and iron blocks of equal mass, same initial temperature, and same amount of heat added, the one with the lower specific heat (Au), will require less heat for each degree of temperature change and will have the higher final temperature.

c) $\frac{.129 \text{ J}}{\text{g}^\circ\text{C}} \times \frac{196.97 \text{ g}}{1 \text{ mol}} = \boxed{25.4 \text{ J/mol}^\circ\text{C}}$