Chemistry 12

Solutions Manual Part A

Unit 3 Energy Changes and Rates of Reaction

Answers to Unit 3 Preparation Questions

(Student textbook pages 272-5)

1. a. WHMIS symbol for flammable and combustible material. Precaution: Be aware of the location of the nearest fire extinguisher and type of fire for which the extinguisher can be used; ensure a fire blanket is available and a working fire alarm is nearby; Stop, Drop, Roll if clothing is ignited.

b. Safety symbol for thermal safety. Precaution: Check glassware for cracks before heating; do not allow a glass container to boil to dryness; when heating, point test tubes away from yourself and others; use thermal gloves to handle extremely hot or cold objects.

c. WHMIS symbol for corrosive material. Precautions: wear eye protection, a lab apron, and safety eyewear; use a safety shield; know location of eyewash station; report any spills and dispose of chemicals as directed by your teacher.

d. Safety symbol for chemical safety. Precautions: wear eye protection, gloves, and lab apron; use a safety shield; know location of eyewash station; report any spills and dispose of chemicals as directed by your teacher.

2. a. Symbols c and d since hydrochloric acid is corrosive and even though it is dilute in this activity, it will irritate the skin and is dangerous to the eyes.

b. Symbol b as a reminder that the object is hot.

3. A spill of sodium hydroxide should be washed from the skin with copious amounts of water. Adding hydrochloric acid will neutralize the base, but the acid is also corrosive. Having two corrosive chemicals on the skin increases the chance for injury. Also the reaction between hydrochloric acid and sodium hydroxide will generate some heat, which could result in a burn.

4. a. To set up the Bunsen burner, you would do the following:
- place the burner to the side of the stand; do not try to light the burner when it is under the beaker
- close the air inlet
- make certain the lighting device is working to give a spark or flame
- turn the gas source on full and ignite the gas with the lighter; the flame will be yellow.
- open the air inlet to allow air to mix with the gas; continue this adjustment until the yellow disappears and the flame is blue.

b. To safely heat the water, you would do the following:
- Wear safety apron and protective eyewear.
- Before beginning, check that the beaker has no cracks.
- Do not leave the burner unattended during the heating.
- Secure the burner to the stand.
- Ensure the beaker is safely secured to the stand.
- Ensure you are using a large enough beaker that you do not need to fill it much more than half full.
- Unless specifically directed, do not boil the water; heat to the desired temperature using a thermometer to track the temperature.
- Handle the hot beaker carefully with beaker tongs and thermal mitts if available.

c. To safely handle the accidental spill you would:
- Inform the teacher immediately.
- Get treatment if anyone has been burned.
- Avoid touching the broken glass with bare hands.
- Collect broken glass with broom and dustpan. Dispose of glass in “Broken Glass Container.” Do not mix broken glass with garbage.

5. e

6. A force is applied to the crate that sets it in motion; work is being done on the crate to move it. In other words, energy is transferred to the crate to move it; the person doing work on the crate caused the kinetic energy of the crate to increase

7. **a.** *Gravitational potential energy*: A (the skier is at rest at the top of a hill)

   Gravitational potential energy and kinetic energy: B (the skier is moving but has not yet reached the bottom of the hill)

   b. In photo A, the skier is at the top of the hill and has high potential energy, given her position; gravitational potential does work to begin movement, causing an increase in kinetic energy; the kinetic energy of the skier increases and the gravitational potential energy decreases as she moves down the hill

8. **a.** chemical energy: battery

   b. electrical energy: energy that is transmitted via the wires from the battery to the light bulb

   c. electromagnetic energy: light given off by the light bulb

   d. thermal energy: when the light bulb is lit it releases thermal energy (begins to feel warm)

   e. heat: as the light bulb warms up, thermal energy is transferred from it to the surroundings

9. d

10. *Sample answer*: Heat represents the quantity of thermal energy that is transferred between an object or area of higher temperature to one of lower temperature.

11. Student presentations should include key points about the kinetic molecular theory; for example, the particle nature of matter, the differences in the energy of particles, the distance between particles, and the forces among particles in the three different states. Particles should be represented pictorially in the solid, liquid, and gas phases.

12. According to the kinetic molecular theory of gases, air (a mixture of gases) is composed of particles that move in a random motion and can readily diffuse. Bees move their wings to cause drafts, allowing warm air to escape the hive and cooler air to enter. (Student research may also reveal that bees bring in water and move their wings to encourage evaporation by moving moist air out and dry air in. Evaporation is a process that absorbs thermal energy, cooling the hive.)

13. a

14. Graphic organizers should indicate the following key points: matter in all three states is composed of particles in motion; the behaviour of the particles differs in each state. Solids retain a constant shape and volume; particles are packed close together and in a fixed framework. Liquids have variable shape and constant volume; particles are less organized and farther apart than in solids and are not in a fixed position (can slide over each other). Gases have variable shape and volume; particles are much less organized and much farther apart than in other states and bounce off each other and walls of container. In terms of motion, particles in solids vibrate; particles in liquids have primarily rotational motion; particles in gases have primarily translational motion.

15. b

16. A room temperature diagram will show particles moving randomly in straight lines at a speed of v_1. At a lower temperature outside in the winter, the particles are again moving randomly but at a speed v_2 where $v_2 < v_1$. The number of collisions per unit area of the balloon surface is lower at v_2 resulting in a lower pressure and the balloon begins to deflate.

17. **a.** As methanol cools to −97.7°C, its molecules, which previously moved with vibrational and rotational energy, lose kinetic energy. Their movement becomes predominantly vibrational as molecules form intermolecular bonds. The molecules form a rigid, crystalline structure as the methanol changes from a liquid to a solid.

    b. As methanol heats up to 65°C, the kinetic energy of the molecules increase. The molecules begin to move with translational energy as they break away from the liquid state, overcoming intermolecular attractions. As more and more molecules gain sufficient energy to escape the liquid state and move with translational energy in the gas state, the methanol changes from a gas to a liquid.

18. The rise is the vertical change between two points on the line $(y_2 - y_1)$ and the run is the horizontal change between two points $(x_2 - x_1)$. On this graph, rise represents a change in mass and run represents a change in volume.

19. For the points indicated, the rise is 30 g and the run is 30 mL.

20. slope $= \frac{\text{rise}}{\text{run}}$; 1.0 g/mL

21. $y = 1.0x$

22. The graph represents a direct relationship; as mass increases the volume increases by the same factor.

23. If the slope were steeper, there would be greater change in the y variable for the same change in the x variable. In other words, for every change in unit volume, there would be a greater change in unit mass.

24. a. Graph B represents $\frac{1}{x}$, an inverse relationship

Graph C represents x^n ($n > 1$), an exponential relationship

b. Graph A represents a direct relationship between variables.

25. a. $c_{\text{mean}} = \dfrac{0.54 \text{ mol/L} + 0.491 \text{ mol/L} + 0.51 \text{ mol/L}}{3}$

$= 0.51366 \text{ mol/L}$
$= 0.51 \text{ mol/L}$

b. $m = nM$

Find n:

$n = cV$

$= 0.51366 \dfrac{\text{mol}}{\cancel{\text{L}}} \times 25 \cancel{\text{mL}} \times \dfrac{1 \cancel{\text{L}}}{1000 \cancel{\text{mL}}}$

$= 0.01284 \text{ mol}$

Use n to find m.

$m = nM$

$= 0.01284 \cancel{\text{mol}} \times 45.6 \dfrac{\text{g}}{\cancel{\text{mol}}}$

$= 0.58558 \text{ g}$
$= 0.59 \text{ g}$

26. a. $y = 3$

b. $x = 2$

27. a. 0.583 L

b. 4.7×10^3 cm/s

Chapter 5 Energy Changes

Answers to Learning Check Questions

(Student textbook page 283)

1. *Sample answer*: The heating element on an electric stove transfers heat to a metal pot, which transfers heat to the water inside; hot water in a wash basin transfers heat to your hands; a person exercising transfers body heat to the surrounding air.

2. A closed system can exchange energy with its surroundings in forms such as thermal energy, mechanical energy, and chemical energy. For example, a hot object in a closed, metal container can transfer thermal energy to the metal container and then to the surroundings because the hot object, metal container, and surroundings are in thermal contact.

3. Under conditions of constant pressure and volume, the enthalpy change of a system is equal to the heat exchanged between the system and the surroundings.

4. The burning of fuel in an automobile occurs in an open system. It is not possible to isolate the combustion reaction that occurs in an automobile engine. Thermal energy is continually released to the surroundings and dispersed. Under laboratory conditions, the combustion of a fuel could be studied in a controlled manner with all released thermal energy accounted for. The second law of thermodynamics would be shown to be valid. This tells us that when studying chemical reactions, the immediate surroundings must be isolated from the system for the results to be accurate.

5. An endothermic process is one in which the enthalpy or heat content of the system increases. Thermal energy is absorbed by the system. An exothermic process is one in which the enthalpy or heat content of the system decreases. Thermal energy is given off by the system.

6. a. The products have greater potential energy.

b. The enthalpy of the system is increasing: the reaction is endothermic; the enthalpy change is positive.

(Student textbook page 295)

7. The enthalpy term is a product in a thermochemical equation. The negative value for the enthalpy change means that energy is released.

8. Energy is released by the system, so the products have a lower potential energy than the reactants. The reactants, therefore, have more potential energy.

9. $C_2H_6(g) + \frac{7}{2} O_2(g) \rightarrow$
$2CO_2(g) + 3H_2O(\ell) + 1560.7 \text{ kJ}$

10. The diagram should indicate that the vertical scale measures potential energy in kilojoules per mole. The reactants, $C_3H_6(\ell) + \frac{9}{2} O_2(g)$, are at a higher energy level than the products, $3CO_2(g) + 3H_2O(\ell)$, with an energy difference of 2091.3 kJ.

11. $C_7H_6O_2(s) + \frac{15}{2} O_2(g) \rightarrow$
$7CO_2(g) + 3H_2O(\ell) + 3228.2 \text{ kJ}$

$\Delta H^\circ_{\text{comb}} = -3228.2 \text{ kJ/mol of } C_7H_6O_2(s)$

12. The equation for complete combustion of methyl methanoate is as written:

$C_2H_4O_2(\ell) + 2O_2(g) \rightarrow$
$2CO_2(g) + 2H_2O(\ell) + 972.6 \text{ kJ}$

The equation for complete combustion of methyl ethanoate is as shown below (divide the given equation by 2):

$C_3H_6O_2(\ell) + \frac{7}{2} O_2(g) \rightarrow$
$3CO_2(g) + 3H_2O(\ell) + 1592.2 \text{ kJ}$

More heat is given off for $C_3H_6O_2(\ell)$ than for $C_2H_4O_2(\ell)$. The standard molar enthalpy of combustion for $C_3H_6O_2(\ell)$ is -1592.2 kJ/mol.