Energy

Aim

- understand the role of energy in chemical reactions
- calculate energy changes from mass, specific heat, and temperature data
- compare the celsius an Kelvin temperature scales

Notes

Definition: Energy = the ability to do work

Types of energy

- Kinetic energy = energy of motion
- Potential energy = stored energy
  - atomic energy - energy stored in the nucleus of an atom [$E = mc^2$]
  - chemical energy - energy stored in chemical bonds

Energy and chemical reactions

- **Exothermic** - reactions that release energy
  - Burning wood
- **Endothermic** - reactions that absorb energy
  - Photosynthesis
- **Activation energy** - energy needed to start a chemical reaction
  - Lighting a barbecue

Heat and Temperature

- heat = kinetic energy of molecules
- temperature = average kinetic energy
  - specific heat (heat capacity)
    - definition - amount of heat needed to increase the temperature of a gram of a substance by 1°C
    - specific heat of water = 4.18 J/g°C
  - Units of energy
    - joule (J) – SI unit of work or energy, defined as the energy of a mass of two kilograms moving at a velocity of 1 m/sec.
    - joule (J) – amount of heat needed to increase the temperature of 1gram of a water by 0.239°C
- Measuring heat energy

$$\mathbf{Q = m \times \Delta T \times c_p}$$

Q = heat energy ΔT = change in temperature

m = mass of water c_p = specific heat capacity of water

  - specific heat capacity of water – 4.18 kJ/kg°C, 4.18 J/g°C, or 0.00418 kJ/g°C
  - mass of water: D = 1 g/mL $\therefore \quad 1g_{H_2O} = 1mL_{H_2O}$

Temperature scales

- Celsius scale - based on water
  - Freezing point = 0°C
  - Boiling point = 100°C
- Kelvin scale - scale based on the Celsius scale with the zero at absolute zero
  - Absolute zero is the lowest possible temperature
  - Absolute zero is the temperature at which particles of matter stop moving
    - K = °C + 273 and °C = K – 273

Answer the questions below by circling the number of the correct response

1. Which temperature represents absolute zero? (1) 0 K (2) 0°C (3) 273 K (4) 273°C

2. At which temperature does a water sample have the highest average kinetic energy (1) 0°C, (2) 100°C, (3) 0 K, (4) 100 K

3. When 83.6 joules of heat is added to 2.0 gram of water at 15°C, the temperature of the water increases to (1) 5.0°C, (2) 15°C, (3) 25°C, (4) 50. 0 C

4. Which Kelvin temperatures represent, respectively, the normal freezing point and the normal boiling point of water? (1) 0 K and 273 K (2) 0 K and 100 K (3) 100 K and 273 K (4) 273 K and 373 K

5. How many joules of heat energy are released when 50 grams of water are cooled from 70°C to 60°C? (1) 41.8 joules (2) 209 joules (3) 2090 joules (4) 4,180 joules

6. The number of joules needed to raise the temperature of 10 grams of' water from 20°C to 30°C is (1) 41.8, (2) 83.6, (3) 418, (4) 167

7. Which of the following best describes exothermic chemical reactions? (1) They never release heat. (2) They always release heat. (3) They never occur spontaneously. (4) They always occur spontaneously.

8. A 5-gram sample of water is heated and the temperature rises from 10°C to 15°C. The total amount of heat energy absorbed by the water is (1) 104.5 J, (2) 83.6 J, (3) 62.7 J, (4) 20.9 J

9. At which temperature would the molecules in a one gram sample of water have the lowest average kinetic energy? (1) 5°C (2) –100°C (3) 5 K (4) 100 K

10. How many kilojoules of heat energy are absorbed when 100 grams of water is heated from 20°C to 30°C? (1) 4.18 kJ (2) 41.8 kJ (3) 418 kJ (4) 0.42 kJ

11. The temperature of a substance changes from -173°C to 0°C. How many Kelvin degrees does this change represent? (1) 100. (2) 173 (3) 273 (4) 446

12. How many kilojoules of heat are needed to raise the temperature of 500. grams of water from 10.0°C to 30.0°C? (1) 41.8 kJ (2) 104.5kJ (3) 209.0 kJ (4) 167.2 kJ

13. When 5 grams of water at 20°C absorbs 10 joules of heat, the temperature of the water will be increased by a total of (1) 0. 5 C° (2) 2 C° (3) 10 C° (4) 50 C°

14. Which Kelvin temperature is equal to -33°C? (1) - 33 K (2) 33 K (3) 240 K (4) 306 K

15. If 4 grams of water at 1°C absorbs 33.44 joules of heat, the temperature of the water will change by (1) 1 C° 2) 2 C° (3) 3 C° (4) 4 C°

16. The molecules of which substance have the highest average kinetic energy? (1) He(g) at 0°C (2) CO_2(g) at 20°C (3) HCl(g) at 40°C (4) N_2(g) at 60°C