

Energy

Aim

- understand the role of energy in chemical reactions
- calculate energy changes from mass, specific heat, and temperature data
- compare the Celsius and 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 1 gram of a water by 0.239°C
- ★ Measuring heat energy

$$Q = m \times \Delta T \times c_p$$

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: $D = 1 \text{ g/mL} \therefore 1 \text{ g}_{H_2O} = 1 \text{ mL}_{H_2O}$

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
 - ☆ $K = ^\circ C + 273$ and $^\circ C = K - 273$

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

- Which temperature represents absolute zero? (1) 0 K (2) 0°C (3) 273 K (4) 273°C
- 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
- 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
- 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
- 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
- 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
- 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.
- 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
- 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
- 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
- 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
- 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
- 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°
- Which Kelvin temperature is equal to -33°C? (1) -33 K (2) 33 K (3) 240 K (4) 306 K
- 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°
- The molecules of which substance have the highest average kinetic energy? (1) He(g) at 0°C (2) CO₂(g) at 20°C (3) HCl(g) at 40°C (4) N₂(g) at 60°C