

Solutions

Each answer shows the steps, then the **result**.

2.1

- with **no resultant external force**, the **total momentum** of a system stays **constant**

2.2

- (a) **elastic: momentum and kinetic energy** conserved
- (b) **inelastic: momentum only** (KE decreases)

2.3

- take right as positive; total momentum after = 0 (they move apart)

$$0 = (2.0 \text{ kg})(6.0 \text{ m s}^{-1}) + (3.0 \text{ kg})(-v) \Rightarrow v = \frac{12 \text{ kg m s}^{-1}}{3.0 \text{ kg}} = \mathbf{4.0 \text{ m s}^{-1}}$$

2.4

- for an elastic collision, **relative speed of approach = relative speed of separation**

3.1 B

- momentum is conserved in **every** collision (equal and opposite forces)
- *inelastic* means kinetic energy is **not** conserved (some becomes internal energy and sound)
- **C** is an *elastic* collision; **A** has it backwards

3.2

- conservation of momentum; the 1000 kg car is at rest

$$(1500 \text{ kg})(12 \text{ m s}^{-1}) + 0 = (1500 \text{ kg} + 1000 \text{ kg})v$$

$$v = \frac{1.8 \times 10^4 \text{ kg m s}^{-1}}{2500 \text{ kg}} = \mathbf{7.2 \text{ m s}^{-1}}$$

3.3

- equal masses, elastic, target at rest: they **exchange velocities**
- first ball **stops** (0 m s^{-1}); second moves off at $\mathbf{4.0 \text{ m s}^{-1}}$

3.4

- equal-and-opposite forces conserve total **momentum**
- kinetic energy can go to **thermal / sound / deformation** energy, so total KE can decrease

3.5

- (a) for a system with **no resultant external force** (isolated)

- **total momentum stays constant:** momentum before = momentum after

(b) take right as positive

$$p_{\text{before}} = (1.6 \text{ kg})(4.5 \text{ m s}^{-1}) + (0.90 \text{ kg})(1.5 \text{ m s}^{-1}) = 8.55 \text{ kg m s}^{-1}$$

- they stick, so $m = 1.6 \text{ kg} + 0.90 \text{ kg} = 2.5 \text{ kg}$

$$v = \frac{8.55 \text{ kg m s}^{-1}}{2.5 \text{ kg}} = \mathbf{3.4 \text{ m s}^{-1}}$$

to the right

(c)

$$E_{\text{K, before}} = \frac{1}{2}(1.6 \text{ kg})(4.5 \text{ m s}^{-1})^2 + \frac{1}{2}(0.90 \text{ kg})(1.5 \text{ m s}^{-1})^2 = 17.2 \text{ J}$$

$$E_{\text{K, after}} = \frac{1}{2}(2.5 \text{ kg})(3.42 \text{ m s}^{-1})^2 = 14.6 \text{ J}$$

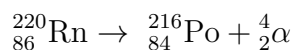
$$\frac{17.2 \text{ J} - 14.6 \text{ J}}{17.2 \text{ J}} \times 100\% = \mathbf{15\%}$$

(d) **not elastic**

- kinetic energy is not conserved: about 15% goes to thermal and sound energy and to deforming the trolleys

3.6

(a) nucleon and proton numbers both balance



(b) the nucleus is stationary, so total momentum stays **zero**

- the fragments carry equal and opposite momentum; u cancels

$$4u \times v_{\alpha} = 216u \times 2.2 \times 10^5 \text{ m s}^{-1}$$

$$v_{\alpha} = \frac{216 \times 2.2 \times 10^5 \text{ m s}^{-1}}{4} = \mathbf{1.2 \times 10^7 \text{ m s}^{-1}}$$

opposite to the Po

(c) any **three** of: **momentum, total energy, charge (proton number), nucleon number**

- kinetic energy is **not** conserved — it is created from the nucleus's store of energy

(d) momenta equal in magnitude, and $E_{\text{K}} = p^2/(2m)$

- for the same p , KE is **inversely proportional to mass**

$$\frac{E_{\alpha}}{E_{\text{Po}}} = \frac{m_{\text{Po}}}{m_{\alpha}} = \frac{216}{4} = \mathbf{54}$$