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** ($0\ \text{m s}^{-1}$); second moves off at **4.0** 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 $m = 1.6\text{ kg} + 0.90\text{ kg} = 2.5\text{ kg}$

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

to the right

(c)

$$E_{\text{K,before}} = \tfrac{1}{2}(1.6\text{ kg})(4.5\text{ m s}^{-1})^2 + \tfrac{1}{2}(0.90\text{ kg})(1.5\text{ m s}^{-1})^2 = 17.2\text{ J}$$
$$E_{\text{K,after}} = \tfrac{1}{2}(2.5\text{ kg})(3.42\text{ m s}^{-1})^2 = 14.6\text{ J}$$
$$\frac{17.2\text{ J} - 14.6\text{ J}}{17.2\text{ J}} \times 100\% = \mathbf{15}\%$$

(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

$${}^{220}_{86}\text{Rn} \rightarrow {}^{216}_{84}\text{Po} + {}^{4}_{2}\alpha$$

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

- the fragments carry equal and opposite momentum; u cancels

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

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

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 $E_K = p^2/(2m)$

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

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