Answers to Selected Questions

See our Web page for worked solutions to three star (***) questions. The address is on the back cover.

Chapter 1

1 (a) luminous intensity, temperature; **(b)** ampere, second; **(c)** yard, year **2 (a)** 1.08×10^{9} km h^{-1}; **(b)** 6.71×10^{8} miles/h **3 (a)** 1030 cm; **(b)** 0.0125 m; **(c)** 11.20 m; **(d)** 143.367 m; **(e)** 1.8×10^{-3} m; **(f)** 1.4×10^{-3} m^2; **(g)** 4.8×10^{-6} m^3 **4 (a)** 172.72 cm; **(b)** 10.72575 kg **5 (a) (i)** is larger; **(b)** use scientific notation; **(c) (i)** 1×10^{-1} s, **(ii)** 1×10^{-5} s **6 (a)** 5.52×10^{-4}; **(b)** 7.3×10^{7}; **(c)** 1.5×10^{6}; **(d)** 2.50×10^{-4} **7 (a)** 2.64×10^{-7}; **(b)** 2.8125×10^{10} **8** 5×10^{-28} m^3 **9 (a)** 4; **(b)** 3; **(c)** 1; **(d)** 4; **(e)** 1; **(f)** 6; **(g)** 4; **(h)** 5; **(i)** 1; **(j)** 4; **(k)** 3 **10 (a)** 8.383×10^{1}; **(b)** 2.00×10^{1}; **(c)** 5; **(d)** 2.205×10^{4}; **(e)** 1×10^{2}; **(f)** $1.000\ 10 \times 10^{2}$; **(g)** 1.999×10^{3}; **(h)** 2.222 2; **(i)** 4×10^{4}; **(j)** 5.070×10^{-2}; **(k)** 2.00×10^{-7} **11 (a)** 2; **(b)** 3; **(c)** 3; **(d)** 4 **12 (a)** 4.20×10^{2} m^2; **(b)** 7.6×10^{6} m^2; **(c)** 7.2×10^{1} cm s^{-1}; **(d)** 3.71 cm^2; **(e)** 4.0×10^{-7} **13 (a)** 45.6; **(b)** 22.611; **(c)** 3.3×10^{4} m or 0.00034; **(d)** 5.4×10^{-2} or 0.054; **(e)** 2.35×10^{6} or 2 350 000; **(f)** 3.5×10^{-2} or 0.035 **14** 0.2 kg cm^{-3} **15 (a)** 110 cm^2; **(b)** 2 cm^3; **(c)** 115.0 cm **16 (a)** 10^{22}; **(b)** 10^{13}; **(c)** 10^{-10}; **(d)** 10^{-14}; **(e)** 10^{5}; **(f)** 10^{5}; **(g)** 10^{-6}; **(h)** 10^{-3} **17 (a)** 10^{3} or 10^{4} if converted to OM first; **(b)** 10^{12}; **(c)** 10^{3} or 10^{4} if converted to OM first **18** 2200 ± 300 mm^3 **19 (a)** 25.5 ± 0.5 mm, 174.5 ± 0.5 mm; **(b)** 25.5 mm ± 1.96%, 174.5 mm ± 0.29%; **(c)** 200.0 ± 1.0 mm; **(d)** 4450 ± 100 mm^2 **20** 223 000 ± 5000 m^2, 1980 m ± 20 m **21 (a)** 27.6 ± 0.41; **(b)** 10.35 ± 0.06 **22 (a)** 5.3%; **(b)** 5.3%; **(c)** 5.3%; relative error remains the same even as the speed changes **23** 330 ± 20 ohms **24 (a)** 8.49 cm; **(b)** 9.8 mm **25** 3×10^{8} mm **26 (a)** 4.00×10^{7} m; **(b)** 1.08×10^{21} m^3; **(c)** 1.08×10^{12} km^3 **27** 66 m s^{-1} **28 (a)** 3.55876×10^{3}; **(b)** 40.00 (or 4.000×10^{1}; **(c)** 7.9×10^{4}; **(d)** $2.003\ 26 \times 10^{5}$; **(e)** 1.994×10^{3}; **(f)** 20.009 (or 2.0009×10^{1}; **(g)** 5.00×10^{-2}; **(h)** 2.5×10^{6}; **(i)** 8×10^{-7}; **(j)** 5×10^{6} **29 (a)** 3.4×10^{8}; **(b)** 1.5×10^{4}; **(c)** 4.0×10^{-2}; **(d)** 3.0×10^{9}; **(e)** 5.3×10^{-11}; **(f)** 6.4×10^{15} **30 (a)** 10^{8}; **(b)** 10^{8}; **(c)** 10^{5}; **(d)** 10^{-4}; **(e)** 10^{-7}; **(f)** 10^{7}; **(g)** 10^{-6} **31 (a)** 3; **(b)** 4; **(c)** 2; **(d)** 3 **32 (a)** 2.40 V ± 0.8%; **(b)** 3.25 A ± 2%; **(c)** 25.4 mm ± 2%; **(d)** 0.0035 T ± 3%; **(e)** 325 cm ± 3% **33 (a)** micrometer ± 0.005 mm, vernier ± 0.05 mm; **(b)** 28.4 mm length, 16.444 mm diameter; **(c)** radius = 8.222 ± 0.005 mm (± 0.0608%), length = 28.4 ± 0.05 mm (± 0.176%); **(d)** 6030 mm^3 ± 0.2976% (± 17.9 mm^3); **(e)** 9.35×10^{-3} g mm^{-3} ± 0.648% **35** *Micro* means small wavelength; *pico* means smaller still **36** 1.8×10^{12} furlongs/fortnight **37** $1.1 \times 10^{-2} \pm 7 \times 10^{-4}$ g/mm **38** 3×10^{23} fermi **39** \$690 (to 2 SF) **40** 3×10^{7} words **42 (b)** 11 March; **(c)** 2 h 56 min **43** 3.25×10^{-6} m **44** True, 8.33×10^{24} molecules in glass, 5.21×10^{21} glasses in ocean **45** 5.97×10^{10} kg

Chapter 2

1 (a) 2 km N; **(b)** 8 km; **(c)** 6 km; **(d)** 4.5 km E26°N **2** 60 m East **3 (a)** 188 cm, 120 cm; **(b)** 377 cm, 0 cm; **(c)** 754 cm, 0 cm; **(d)** 94 cm, 85 cm **4 (a)** 20 m s^{-1}; **(b)** 9.3 m s^{-1} (33 km h^{-1}); **(c)** 4200 m; **(d)** 660 km; **(e)** 20 s; **(f)** 2 hours **5** 0.26 s **6** 4.8 s **7 (a)** speed 3.89 m s^{-1}; **(b)** velocity 2.78 m s^{-1} N53°W **8** 28 m s^{-1} **9 (b)** 2–4 s, 5–6 s; **(c)** 0–2 s, 4–5 s; **(d)** same at 0–2 s, 5–6 s, 6–9 s **10 (a)(i)** 6 m s^{-1}, **(ii)** 0 m s^{-1}, **(iii)** 4 m s^{-1}, **(iv)** 0 m s^{-1}, **(v)** –5.0 m s^{-1}; **(b)** 0; **(c)** 3.3 m s^{-1} **11** 6 m s^{-2} **12 a)** 8 m s^{-1}, 4 m s^{-2}; **(b)** 38 m s^{-1}, 1.0 s; **(c)** 0 m s^{-1}, –20 m s^{-1}; **(d)** –7 m s^{-1}, –2 m s^{-2}; **(e)** –5.65 m s^{-1}, –0.65 m s^{-1} **13** 6.7 m s^{-2} **14** 69 s **15** 0.54 s **16** 4×10^{-8} s **17 (a)** approx. 13 m s^{-1}; **(b)** 10 m s^{-1} **18 (a)** displacement 100 m, distance 200 m; **(b)** 0.5 m s^{-2}, –1 m s^{-2}, 1 m s^{-2}; **(d)** 0 s, 30 s, 50 s; **(e)** 0–20 s, 20–40 s, 40–50 s; **(f)** nowhere **19 (a)** 150 m; **(b)** 350 m; **(c)** 20–30 s, a = –1.5 m s^{-2}; **(d)** 0s, 30 s, 60 s; **(e)** 20–30 s, 30–40 s; **(f)** 40–50 s **20 (b)** 15.7 km **21** 11.25 m, 7.5 m s^{-1}; **(b)** 83 m s^{-1}, 34.7 m s^{-2}; **(c)** 131.25 m, 7.5 s; **(d)** 31.3 m s^{-1}, 14.9 s; **(e)** 18 m s^{-1}, 4 s; **(f)** 18.75 m, –2 m s^{-2}; **(g)** –10 m s^{-1}, –7.5 m s^{-2} **22 (a)** 6 m s^{-2}; **(b)** 36.75 m **23** 0.18 m s^{-2} **24** 6.4×10^{-4} s **25** 80 m **26 (a)** –22.3 m s^{-1}; **(b)** 2.23 s **27 (a)** 61.2 m; **(b)** 3.5 s; **(c)** same, 3.5 s **28 (a)** 4.9 s; **(b)** –44.5 m s^{-1} **29 (a)** 3.72 m s^{-1}; **(b)** 1.72 m s^{-1}; **(c)** 15 cm higher **30** constant acceleration of –10 m s^{-2} **31** A **33 (b)** slope at C = 57 cm s^{-1}, slope at F = 140 cm s^{-1}, same as calculated v; **(d)** area = 10 cm, about same as displacement at G; **(e)** slope = 1375 cm s^{-1} approx., about same as calculated acceleration **34 (c)** 90 cm s^{-1}; **(e)** same; **(g)** 1100 cm s^{-2}; **(i)** same; **(j)** area = 6 cm, about same as table 6.1 cm **35** 20 s, 300 m **36** No, v = 60 km h^{-1} **37 (a)** 50 m s^{-1}; **(b)** 33.3 km h^{-1}; **(c)** 10 200 m; **(d)** 715 m; **(e)** 20 s; **(f)** 55 846 h or 6.15 y **38 (a)** 18.77 km h^{-1}, 5.2 m s^{-1}; **(b)** 3940 s or 1 h 5 m 41 s **39 (a)** 4023 m; **(b)** 42.116 m s^{-1} or 151.6 km h^{-1} **40** 0.55 s **41 (a)** 76 m north; **(b)** 9 m s^{-1}; **(c)** 2.8 m s^{-1} N **42** 35 km h^{-1} **43 (a)** 15 m; **(b)** 40 m; **(c)** 0–1 s; **(d)** 1–4 s; **(e)** 0–1 s, 4–6 s; **(f)** –12.5 m s^{-1} **44 (a)** 17 m s^{-2}; **(b)** –82 m s^{-2}; **(c)** 244 m s^{-1}; **(d)** 6.9 s; **(e)** 6.7×10^{-3} s; **(f)** 2.4×10^{-3} m s^{-1} **45 (a)** 10.3 m s^{-2}; **(b)** 18.5 m s^{-1}; **(c)** 29 m; **(d)** 20.5 m s^{-1} **46 (a)** 162.5 m; **(b)** 392.5 m; **(c)** 50–60 s; **(d)** 0 s, 37 s, 60 s; **(e)** at no stage **47 (a) (i)** 3.375 m, **(ii)** 4.5 m s^{-1}; **(b) (i)** 286 m s^{-1}, **(ii)** 204 m s^{-2}; **(c) (i)** 735 m, **(ii)** 17.3 s; **(d) (i)** 40.3 m s^{-1}, **(ii)** 13.1 s; **(e) (i)** 17 m s^{-1}, **(ii)** 20 s; **(f) (i)** 44.5 m, **(ii)** –9.3 m s^{-2}; **(g) (i)** –72 m s^{-1} **(ii)** –0.19 m s^{-2} **48 (a)** 27.8 m; **(b)** 5.5 s **49 (a)** 10.2 m; **(b)** 2.1 s **50** 6.7 m s^{-2} **51** 64.9 m s^{-2} **52** 0.021 s **53 (a)** 396 m s^{-2}; **(b)** 1.89 s **54 (a)** 3 061 224 s (35.4 days); **(b)** 4.6×10^{13} m **55 (a)** –4 m s^{-2}; **(b)** 50 m; **(c)** 8.5 s; **(d)** –20 m s^{-1}; **(e)** –14.1 m s^{-1} **56 (a) (i)** 2 s, **(ii)** 5 m; **(b) (i)** +45 m s^{-1}, **(ii)** 9 s; **(c) (i)** +27.5 s, **(ii)** +38 m **57 (a)** –22.6 m s^{-1}; **(b)** 2.6 s **59 (a)** liberty; **(b)** none; **(c)** yes; **(d)** 40 km h^{-1} = 11.1 m s^{-1}, 70 km h^{-1} = 19.4 m s^{-1}; **(e)** price, mass, fuel consumption, warranty, accessories etc.; **(f)** not true — could depend on mass of car as well; **(g)** not supported — mass could have an effect **60** Chris is still faster **61** –14.3 m s^{-2} **62 (a)** 23.87 m s^{-1}; **(b)** 75.3 s **63 (a)** 0.04 s; **(b)** 0.17 s; **(c)** bottom is about 1/4 of time **64** Four times as high **65 (a)** –11.7 m s^{-1} **66** Acceleration most thrilling. Kitty: 46.9 m s^{-2}, Eli: 805 m s^{-2} **67** Both the same **68 (a)** $s_1 - s_2 = 10 - 10t_1$; **(b)** $v_1/v_2 = t_1/(t_1 - 1)$ **69** Case 1: a = 15.4 m s^{-2}, Case B: a = 11.8 m s^{-2}. The Case 1 rider probably reached top speed before the 400 m line. The rider in Case 2 was travelling at 305 km h^{-1} at the finish line but reached this after 5 s and held the speed constant **70** At current mass, a = 16.7 m s^{-2}; at heavier mass, a = 15.7 m s^{-2} **71 (a)** 30 knots = 30 nautical miles/h; **(b)** 54.9 km h^{-1} **73** 38.843 058 mph or 119.813 82 mph. See our Web Page for the solution **74** $s \propto t^2$ (correct), $v \propto s$ (incorrect, should be $v^2 \propto s$); **75** 160 s; **77** at 0 m, 4 m, 16 m, 36 m, 64 m

Chapter 3

1 (a) 12.2, 0.70, 35°; **(b)** 10.2, 0.61, 52°; **(c)** 17.9, 0.45, 27°; **(d)** 206, 0.25, 14° **2 (a)** 36 m, N56°E; **(b)** 34 m s^{-1}, W62°S; **(c)** 22.3 N, W71.6°N **3 (a)** 30 N, 53° to horizontal; **(b)** 3.1×10^{-3} N, E36°N; **(c)** 440 N, E8.2°N **4** Scalar: mass, height, time; Vector: velocity, acceleration, displacement **5** 29 N, S21.6°W **6 (a)** 50 m s^{-1} North; **(b)** 60 m s^{-1} E; **(c)** 43 m s^{-1} E35.5°S; **(d)** 53.8 m s^{-1} N22°W **7 (a)** 28 m s^{-1} up; **(b)** 39 m s^{-1} N39.8°E; **(c)** 28 km h^{-1} at E45°S **8** 40 m s^{-1} vertical **9** $\boldsymbol{F}_V$ = 50 N; $\boldsymbol{F}_H$ = 87 N **10 (a)** $\boldsymbol{F}_H$ = 75 N; **(b)** $\boldsymbol{F}_V$ = 27 N **11 (a)** $\boldsymbol{F}_P$ = 321 N; **(b)** $\boldsymbol{F}_\perp$ = 383 N **12 (a)** 8 m s^{-1} W; **(b)** 8 m s^{-1} E; **(c)** 4 m s^{-1} W **13** Increases their speed relative to the air **14** 7.06 h **15 (a)** 0.5 h; **(b)** 1.0 h **16 (a)** 4.9 m s^{-1} N24°E; **(b)** 44.4 m **17 (a)** heads west; **(b)** 33.3 h; **(c)** 18 km h^{-1} W; **(d)** must head south; **(e)** 44.7 h; **(f)** 13.4 km h^{-1} **18 (a)** treble W; **(b)** halve W **19 (a)** A; **(b)** D; **(c)** B; **(d)** C **21 (a)** 3.14 cm, 0.325 m/y, 6.0 m/s; **(b)** 44 cm, 1.625 m, 48 m; **(c)** 18.8 cm, 0.81 m, 18 m **22 (a)** 2 m west; **(b)** 7.1 m s^{-1} E45°S; **(c)** 5.8 m s^{-2} N56°W; **(d)** 9.2 m W22.4°N **23 (a)** 23.5 m, W12°S; **(b)** 50 m, E33°N; **(c)** 24.8 m S48°E; **(d)** 2 m north **24 (a)** 175 km h^{-1} rebound; **(b)** 75 km h^{-1} W37°S; **(c)** 27.0 m s^{-1} 80° to horizontal; **(d)** 451 m s^{-1} E53°N **25 (a)** 100 km N, 0 km E; **(b)** north component 43 m s^{-1}; east component 25 m s^{-1}; **(c)** north 19 N, east 16 N **26 (a)** 13 m s^{-1} N67°E; **(b)** 60 s; **(c)** 720 m **28** $H \propto I^2$ **29 (a)** 0–4 y, 23.6 cm/y; **(b)** 17–18 y, 52 kg/y; **(c)** sickness, –27 kg/y; **(d)** height, 10.3 cm/y; mass 8.71 kg/y; **(e)** height, 242.5 cm; **(f)** height 285 cm; **(g)** birth height and mass not zero **30** 16 m s^{-1} S; **(b)** 11.3 m s^{-1} W45°S; **(c)** 5.0 m s^{-1} W18°S **31 (a)** 87 N; **(b)** 50 N **32** 502.5 km h^{-1} E5.7°S **33 (a)** $A_P = A_Q/16$; **(b)** $V_P = V_Q/64$; **(c)** $m_P = m_Q/64$; **(d)** $\rho_P = \rho_Q$ **34 (a)** $r_1 = \sqrt[3]{35}\, r_2$; **(b)** r_2 = 15.3 cm **35 (a)** 600 N; **(b)** 800 N **36** 38° **37** 0.098 m, 100 Ω **38** n = 3 has sharper curve

Chapter 4

1 (a) 2.5 N N; **(b)** 101 N up; **(c)** 32 N, S72°W; **(d)** 16 N, N22°W **2 (a)** balanced; **(b)** Unbalanced. $\boldsymbol{F}_W$ causes book to accelerate downwards **3 (a)** Slowly: string A breaks because string A has to support the weight of the mass plus the pulling force; **(b)** String B breaks because of the inertia of the mass. String A would not experience the pulling force immediately **5** 0.123 kg **6** No! V = 1.76 m^3, m = 424 kg **7 (a)** 2941 N, 2.94 m s^{-2}; **(b)** 3.3 m s^{-1}, 1.67 m s^{-2}; **(c)** 100 kg, 3 s; **(d)** 5.5×10^{-4} N, -2.78×10^{-3} m s^{-2}; **(e)** 68 kg, 8.8 m s^{-1} **8** 9000 N **9** 96 000 N **10 (a)** false; **(b)** true; **(c)** true; **(d)** false **11 (b)** $\boldsymbol{F} \propto \boldsymbol{a}$ **12 (b)** $\boldsymbol{F} \propto \boldsymbol{a}$; **(c)** equal: m = 0.850 kg; **(d)** Steeper and wouldn't pass through origin. Need more $\boldsymbol{F}$ to produce the same acceleration; **(e)** Keep the hanging mass at 100 g and remove masses from trolley **13 (a)** Racquet pushes back; **(b)** Road pushes up and forward on horse; **(c)** Ground pushes up and forward on horse and log; **(d)** Ground pushes up on beetle **14 (a)** $\boldsymbol{F}_N = -\boldsymbol{F}_W$ = 25 N up; **(b)** $\boldsymbol{F}_N$ = 5000 N but table would collapse **15 (a)** $\boldsymbol{F}_W$ on Saturn is 1.07 times as great; **(b)** Because of Earth's rotation and shape, the acceleration will be affected **16 (a)** 33 N; **(b)** Use an inertia balance (or springs): convert mass to an equivalent Earth weight $\boldsymbol{F}_W$ = m × 9.8 N **17 (a)** 0; **(b)** 0; **(c)** 735 N; **(d)** 665 N **18 (a)** 246 N; **(b)** 172 N; **(c)** 5.73 m s^{-2} **19 (a)** T = 4 N; **(b)** 2 m s^{-2} **20** Figure (a), **(i)** 5 m s^{-2}; **(ii)** 15 N; Figure (b), **(i)** 2.5 m s^{-2}; **(ii)** 7.5 N **21** 0.55 **22** 35 380 N **23 (a)** 276 N; **(b)** 585 N; **(c)** 0.47 **24** 348 N **25** 56.7 m **26** 10.9 m **27** 13.1 m s^{-1} **28 (a)** 50 N; **(b)** 38 N; **(c)** 43.3 N; **(d)** 66 N **29** 0.47 **30** 0.17 **31 (a)** 25 N north; **(b)** 10.1 N up; **(c)** 36 N, S74°W; **(d)** 1.8 N, W 56° N **32** 202.5 g **33 (a)** 1st; **(b)** 3rd; **(c)** 2nd; **(d)** 1st **34** (a) **35 (a)** 15.36 N east; **(b)** 0.1 N; **(c)** 25 N; **(d)** 1.56 N; **(e)** 3×10^5 N **36 (a)** 0.84; **(b)** same force (2100 N) **37 (a)** 8.8×10^{15} m s^{-2}; **(b)** 1.8761×10^7 m s^{-1} **38 (a)** The retarding (friction) force; **(b)** 1.5 m s^{-2}; **(c)** 2 N, 3 N; **(d)** 1 kg **39** 3.2 N **40 (a)** Sodium 0.97 g cm^{-3}; potassium 0.86 g cm^{-3}; **(b)** No **41 (a)** 3rd law — Throw your jacket off behind you to accelerate; **(b)** 2nd law — The faster you throw, the greater the acceleration; **(c)** 1st law — To change direction, throw something to the side **42** Rolling and sliding friction is independent of area. Starting (static) friction varies with area **44 (b)** 3.3 kg **45 (b)** 0.25 m s^{-2}, 0.175 m s^{-2}, 0.11 m s^{-2}; **(d)** $m \propto 1/\boldsymbol{a}$; **(e)** 0.175 N in each case; **(f) (i)** 0.135 m s^{-2}, **(ii)** 2.72 s **46 (a)** combustion 60%, engine 21.4%, transmission 1.6%, accessories 2.2%, tyres 5.2%, air 4.9%, brakes 4.7%; **(b)** decrease i, ii, v, vi, vii; increase iii, iv **47** Steel plate drags along ground. Loss of control; dig up road **48 (a)** 2.3 N; **(b)** 0.28 **49** Wind force 2.1×10^{-3} N; tension 3.7×10^{-3} N **50 (a)** 2 m s^{-2} upwards; **(b)** 22 s **51** For one person, $\boldsymbol{a}$ = 2.72 m s^{-2}; for two people, $\boldsymbol{a}$ = 2.69 m s^{-2}; one person would go faster **52** 59 m s^{-1} (212 km h^{-1}) **53** 93 N **54** 15 m s^{-1} **55** 14 m s^{-1} **56** 15.3 cm **57** 70 N, 0.58 **58** 16.6 m s^{-1} **59** 15.3 m s^{-1} **61** 464 N

Chapter 5

1 (a) –125 m; **(b)** 125 m; **(c)** –56 m s^{-1} at 63° to horizontal **2 (a)** 4.5 s; **(b)** –46 m s^{-1} 80° to horizontal; **(c)** 36 m **3 (a)** u_V = 12.6 m s^{-1}, u_H = 27.2 m s^{-1}; **(b)** 7.9 m; **(c)** 2.52 s; **(d)** 68.5 m **4 (a)** 1.5 m s^{-1}; **(b)** 20 m s^{-1}, 4.3° (to horizontal); **(c)** 6.6 m; **(d)** 2.3 s; **(e)** 45.8 m **5 (a)** 5.0 s; **(b)** 47 m s^{-1}, 72.7° (to horizontal); **(c)** 70 m **6** 7.3 m s^{-1} **7 (a)** could clear the ferris wheel by 7.0 m; **(b)** 68 m **8 (a)** 12.5 m s^{-1}; **(b)** 23 750 kg m s^{-2} **9 (a)** 13.3 m s^{-2}; **(b)** 94.2 s **10 (a)** 2.4 × 10^{9} m; **(b)** 1023 m s^{-1}; **(c)** 2.7 × 10^{-3} m s^{-2}; **(d)** 2 × 10^{20} kg m s^{-2} **11 (a)** Centripetal force is provided by the force of attraction between the water and the cloth. As long as this force is greater than mv^2/r, the water will remain on the clothes; **(b)** No, you need to increase speed; **(c)** Probably not — the force between the water and the clothes is too strong; **(d)** moves through the cloth **12** 27.8 N **13** 7.74 m s^{-1} **14 (a)** 2550 N; **(b)** 24 m s^{-2}; **(c)** No; **(d)** 50 N; **(e)** 77.4 m s^{-1} **15** 22.5 N **16 (a)** 0.52 rad s^{-1}; **(b)** 0.1 m s^{-1} **17 (a)** 24 rad s^{-1}; **(b)** 3.8 rev/s or 229 rpm **18** Rotation of the Earth; molten core not taken into account **19** 5.48 N m^{-1} **20** Chair 12.5 kg, astronaut 54.4 kg **21 (a)** 1.644 s; **(b)** 1.647 s **22 (a)** 11.3 m s^{-2}; **(b)** 1.02 s; **(c)** 3.3 m s^{-2} **23 (a)** into his hands; **(b)** fall behind him; **(c)** fall to side of him **24 (a)** 31.25 m; **(b)** 37.5 m; **(c)** 29.1 m s^{-1} 59° to horizontal **25 (a)** 4.33 m s^{-1}; **(b)** 17.8 m s^{-1} 76° to horizontal **26 (a)** u_H = 17.2 m s^{-1}, u_V = $^+$24.6 m s^{-1}; **(b)** $^+$30.2 m; **(c)** 4.92 s; **(d)** 84.6 m s^{-1} **27 (a)** $^+$5.3 m s^{-1}; **(b)** 28.2 m s^{-1} at 6° to horizontal; **(c)** $^+$5.26 m; **(d)** 2.1 s; **(e)** 59.2 m **28 (a)** 31.1 m s^{-1}; **(b)** 45°; **(c)** $^+$24 m; **(d)** 4.4 s **29 (a)** 10 m s^{-2}; **(b)** 22 500 N; **(c)** 18.8 s **30** 3 '*g*' or 30 m s^{-2} **31** 9.0 × 10^{22} m s^{-2}; **32 (a)** 57.3°; **(b)** 487°; **(c)** 1.57 rad; **(d)** 0.52 rad s^{-1}; **(e)** 15.9 rev s^{-1}; **(f)** 6.28 m; **(g)** 30 m s^{-1} **33 (a) (i)** 4.1 m s^{-1}, **(ii)** a_c is the same as the ferris wheel is rigid and it is assumed that v is constant; **(b)** at top 383 N, at bottom 917 N **34** 64.7 rpm **35 (a)** 209 rad s^{-1}; **(b)** 136 m s^{-1} **36 (a)** 10 N m^{-1}; **(b)** 0.888 s; **(c)** 1.12 Hz **37 (a)** 1.346 s, **(b)** 1.347 s **38 (a)** 0.42 m; **(b)** 1.3 m s^{-2} **41 (a)** true; **(b)** true; **(c)** true **42** 0.18 m **43 (a)** 4.58 s; **(b)** 45.8° to horizontal; **(c)** 150.7 m **44** He was 0.328 m off maximum (96.5%) **45 (a)** –233 m s^{-1} at angle of 53° to vertical; **(b)** 837 m; **(c)** 263 m s^{-1} at 44.8° to horizontal **46 (a)** 7.2 m s^{-1}; **(b)** 1225 N **47 (a)** 18 m s^{-2} (1.8 g); **(b)** will remain conscious; **(c)** 2240 N **49** 2.2 s **50 (a)** 80 m; **(b)** 76°; **(c)** 12.8 m, 104 m

Chapter 6

2 1.05 × 10^{4} km s^{-1} **3** 3.4 × 10^{4} km s^{-1} **4** 9.8 × 10^{9} y **5** 1.01 × 10^{-6} m **6 (a)** 1.53 × 10^{27} watts; **(b)** 3.9 × 10^{10} **7** Red has longer λ therefore lower temperature **8** False. Will give off radiation with λ = 1.06 × 10^{-5} m **9** False. Twice λ and twice energy but not twice rate **10** 10^{30} **11** expansion **12** least favoured **13** last 10^{37} years **14** true **16 (a)** 2.64 × 10^{9} s; **(b)** 83.5 years **17** 4.51 × 10^{12} m **18** 4.34 × 10^{6} s (50.2 days) **19** 3.54 × 10^{22} N **20** 2.2 × 10^{16} N **21 (a)** 60 m s^{-2}; **(b)** 45 000 N; **(c)** 11.2 min **22 (a)** 0.034 m s^{-2}; **(b)** 2.2 N; **(c)** 465 m s^{-1} **23 (a)** 6100 N; **(b)** 5590 m s^{-1}; **(c)** 4 hours **24 (a)** $\boldsymbol{F}_{g2} = 1/4\ \boldsymbol{F}_{g1}$; **(b)** $\boldsymbol{v}_2 = 0.5\ \boldsymbol{v}_1$; **(c)** $T_2 = 4\ T_1$ **25 (a)** 7279 m s^{-1}; **(b)** 1.8 h **26 (a)** 2.37 km s^{-1}; **(b)** 8900 m s^{-1}; **(c)** 59 500 m s^{-1}; **(d)** 618 000 m s^{-1} **27 (a)** 86.8 N; **(b)** 17.4 m s^{-2} **28 (a)** 7328 N; **(b)** 25.4 N; **(c)** 7302 N; **(d)** 750 kg **29** 0.61 m s^{-2} **30** 3 Earth radii above surface **31** Graph shows $\boldsymbol{g} \propto 1/d^2$ **32** 9.27 × 10^{21} km **33** 0.0427 c **34** 11.0 km s^{-1} Mpc^{-1} **35 (a)** age ∝ 1/H_0 ∴ H_0 of 50 is younger; **(b)** 19.6 billion years **36** 9.38 × 10^{-7} m **37** 32 days **38 (a)** 7.4 × 10^{-12} N; **(b)** 3.56 × 10^{22} N; **(c)** 9 × 10^{-56} N **39** 8.2 m **40 (a)** 0.31 m s^{-2}; **(b)** 708 N; **(c)** 10 670 s (2.96 h) **41 (a)** 14.7 N; **(b)** 9.53 m s^{-2}; **(c)** nil $\boldsymbol{g}$ = 0 **42 (a)** 6254 N; **(b)** 6064 m s^{-1}; **(c)** 3.17 h **43 (a)** 36 176 N; **(b)** 7810 m s^{-1}; **(c)** 5277 s (1.5 h) **44** 640 m s^{-1} **45 (a)** 1.6 m s^{-2}; **(b)** 1.37 s **46 (a)** 9.8 m s^{-2}; **(b)** 1.57 m s^{-2}; **(c)** 0.61 m s^{-2}; **(d)** 1.6 m s^{-2}; **(e)** 275 m s^{-2} **47 (c)** graph shows $\boldsymbol{F} \propto 1/d$ or $1/d^2$; **(d)** confirms $\boldsymbol{F} \propto 1/d^2$; **(e)** slope = 8.35 × 10^{-12} N m^{2} hence G = 6.67 × 10^{-11} N m^{2} kg^{-2}; **(f)** F = 9.2 × 10^{-10} N **48 (a)** third; **(b)** be flat; **(c)** yes – elastic potential energy; **(d)** magnetic boots, velcro; **(e)** no, only that relying on gravity **49** 6400 km **50** Some possibilities **(a)** half the mass but same radius; **(b)** double the radius, keep mass constant; **(c)** double the radius, keep mass constant **51** 0.94 **52** Linear, therefore $r^3 \propto T^2$ **53 (a)** 3.4 × 10^{8} m; **(b)** 0.90 of the distance to the moon; **(c)** No. In circular orbit you would experience free-fall and feel weightless **54 (a)** 9.8011 m s^{-2} — No noticeable difference; **(b)** Same as on Earth's surface — no difference **55 (a)** 9.2 × 10^{11} m s^{-2}; **(b)** 2.8 × 10^{8} m s^{-2} **56** Spring clock not affected by gravity therefore it will keep time. Pendulum won't. They won't agree with each other **57 (a)** 3.54 × 10^{7} m; **(b)** 410 m s^{-1}; **(c)** 0.030 m s^{-2}; **(d)** 1.79 N; **(e) (i)** towards centre of Earth, **(ii)** perpendicular to Earth's axis through Brisbane, **(iii)** towards centre of Earth **58** 4.9 × 10^{10} m s^{-2} (can't escape, ν > c) **59** 6.5 × 10^{23} kg **60 (a)** 3.8 × 10^{-7} m; **(b)** Procycon (bigger surface area); **(c)** Same

Chapter 7

1 1282 Pa **2** 12 000 Pa **3** 1.25 × 10^{6} Pa **4 (a)** 1270 N; **(b)** 5.3 × 10^{5} Pa; **(c)** 120 m **5 (a)** 9690 N; **6 (a)** 8.97 kg, **(b)** 89.7 N, **(c)** 78 N **7** 0.6 g cm^{-3} **8 (a)** 0.8 N; **(b)** 80 g **9** 1670 N **10** 3.8 × 10^{6} N **11** 400 kg **12** 103.36 kPa **13** 307.3 kPa **14** 20 635 Pa **15** 219 600 Pa **16 (a)** 11 000 Pa; **(b)** 112.3 kPa **17 (a)** 401 200 Pa; **(b)** 197 N; **(c)** 269 m **18 (a)** 25 N; **(b)** 4.1 g cm^{-3} **19 (a)** 0.8; **(b)** 800 kg m^{-3} **20 (a)** 150 g; **(b)** 10.05 kg m^{-3} **21** 2.80 **22 (a)** 240 N; **(b)** 11.52 N; **(c)** 228.48 N (= 22.8 kg) **23** 0.02 cm^{-3} (20 kg m^{-3}) **24** 5.5 cm **25 (a)** 0.94 g cm^{-3}; **(b)** 92% submerged **26** Fresh water less buoyant therefore floated at lower level **27** Glass bulb expands and floats higher. Real density would be a lower value **28 (a)**

downward force becomes less therefore rises higher; **(b)** water level in pond will fall; **(c)** perhaps use ball bearing inside a test tube floating in a measuring cylinder **29** Equalise pressure on liquid inside can otherwise the low pressure stops liquid flowing out **30** 1. Weigh in a vacuum (use rigid container); 2. Alternatively weigh a rigid container in air, add the 1 L H_2 and reweigh **31 (a)** 0.58; **(b)** rises **32 (a)** 7.38×10^5 N; **(b)** 74 tonnes **33 (a)** ii; **(b)** ii; **(c)** ii; **(d)** all the same **34** Top and bottom holes — 34.6 cm out from base; middle hole — 40 cm from base **35** No, the water level is the same. The ice cubes have bigger volume than liquid water but the cubes project over the top of the glass **36** H_2 balloon could only lift 1.14 times the load of the He balloon **37** Equal. The weight of water lost from glass equals weight of block **38** Cork will sink. **39** 1087 kg m^{-3} **40** 19.4 kPa **41** 0.5 m **42** 1.47 g cm^{-3} **43** Water level still higher. The water column is 13.6 times the height of the mercury column.

Chapter 8

1 0.92 m from 2.5 kg end **2** 4.61×10^6 m from Earth **3 (a)** 1.6 kg m s^{-1}; **(b)** 30 000 kg m s^{-1}; **(c)** 1.8×10^{29} kg m s^{-1} **4** 10 kg m s^{-1} west **5** 2.57 s **6** 79 200 N s **7** 1.67 m s^{-1} W **8** 0.1 m s^{-1} backward **9** 6.25 m s^{-1} **10** 7.2 m s^{-1} **11** 4.1 m s^{-1} in same direction **12 (a)** 227 m s^{-1}; **(b)** mass of rifle **13 (a)** 11 020 N; **(b)** 53 m s^{-1} **14 (a)** 1.81 m s^{-1} forward; **(b)** –1.86 m s^{-1} (backwards) **15** 31.25 kg **16** 17.39 m s^{-1} at 135° to either neutron **17** 26.9 m s^{-1} S42°E **18** 2.5 m s^{-1} E37°S **19** 3.53 m s^{-1} N38°E **20** 36 N m **21** 5.6×10^{-4} kg m^2 s^{-1} **22** 4×10^{-3} kg m^2 s^{-1} **23** 0.89 m from 20 kg end **24 (a)** 2 kg m s^{-1} E; **(b)** 1.7 kg m s^{-1} N35°E; **(c)** 800 kg m s^{-1} N **25** 1×10^{-22} kg m s^{-1} **26** 66 000 N s **27 (a)** 10.0 N s; **(b)** 45.5 m s^{-1} N **28** 3.25 cm s^{-1} **29** 9 m s^{-1} east **30** 2.25 m s^{-1} **31** 8.8×10^{33} kg m^2 s^{-1} **32** 4.6 m s^{-1} E55°S **33 (a)** air table minimises friction; **(b)** to the right; **(c)** blood pumping in opposite direction (from auricle to ventricle); **(d)** 0.025 m s^{-2}; **(e)** 0.021 kg m s^{-1} **34 (a)** zero; **(b)** 2.09×10^{-20} kg m s^{-1}; **(c)** 53 470 m s^{-1} **35** 34 m s^{-1} at 11° below horizontal **36** 3.5 m s^{-1} S38°E **37** 13 750 m s^{-1}

Chapter 9

1 (a) 87.5 J; **(b)** 170 J; **(c)** 50 000 J **2 (a)** 18 000 J; **(b)** by the piano **3 (a)** Horse A 8400 J, Horse B 6000 J; **(b)** 14 400 J **4 (a)** 400 J; **(b)** 40 000 J; **(c)** 280 J **5** $\boldsymbol{v}_A = 0$, $\boldsymbol{v}_B = 5$ m s^{-1} W **6** 0.25 m s^{-1} **7 (a)** 6 m s^{-1}; **(b)** 432 kJ **8 (a)** 62.5 J; **(b)** 62.5 J **9** 3.3 m **10** 48 200 J **11** 3000 kW **12 (a)** 600 W; **(b)** 3420 W **13 (a)** $E_{k(init)} = 110\,000$ J, $E_{k(final)} = 247\,500$ J; **(b)** 137 500 J; **(c)** 6.875 kW **14** 178 571 N **15** 746 W **16** 13 m s^{-1} **17 (a)** 6384 J; **(b) 6.9** m s^{-1} **18** 150 m s^{-1} **19** 15.3 J **20 (a)** 4 J; **(b)** 200 N m^{-1}; **(c)** 2.89 J **21** 0.04 m **22 (a)** 30%; **(b)** heat; not lost, just transferred **23** 740 J **24** 48 J **25** 1.92 J **26** 210 000 J **27** $E_{k(init)} = 80$ J, $E_{k(final)} = 58.5$ J. Not elastic **28** 700 J **29** 557 W **30** 13 m s^{-1} **31** 4.7 J **32 (a)** 0.36 J; **(b)** 22 N m^{-1}; **(c) (i)** 0.11 J, **(ii)** 0.44 J **33 (a)** run-up 1, take-off 2, flight 3–6; **(b)** at beginning of run $E_k = 0$ and increases; **(c)** no, this is GPE of centre of mass; **(e)** no, lying on back has lower GPE **34 (a)** 1.9 m s^{-1}; **(b)** E_K initial and final is 31.7 J therefore elastic; **(c)** no, can show that $\boldsymbol{v}_1 = -3.9$ m s^{-1} and $\boldsymbol{v}_2 = +3.8$ m s^{-1} and balls can't jump over each other **35** 913 m s^{-1} **36** \$55 per second; \$4.75 million per day **37 (a)** 0.28 km; **(b)** 5.94×10^4 W. **38** 10.7 J **39** 254 N m **40** 1.2 kg **41** 6.0 m s^{-1} (21.7 km h^{-1}) **42** 5 m s^{-1} **44** 31.7 tonnes **46 (a)** 7 m s^{-2}, friction; **(b)** 100 000 N

Chapter 10

2 (a) neither; **(b)** steam **3** Thermal energy **4 (a)** the same; **(b)** 100 mL **5 (a)** 293 K; **(b)** 123 K; **(c)** 793 K; **(d)** 201 K; **(e)** not possible **6 (a)** –223°C; **(b)** 5°C; **(c)** 727°C; **(d)** not possible **7** 1.16×10^5 J **8** 6.3×10^4 J **9** 2.5×10^3 J kg^{-1} K^{-1}; methylated spirits **10** 1.17×10^3 J kg^{-1} K^{-1} **11** 112 s **12** 2.1×10^3 J kg^{-1} K^{-1} **13** 1.6×10^5 J **14** 1.2×10^5 J **15** 8.3×10^5 J **16** 58 min **17** 31°C **21** 2.5°C, 1°C, 0.5°C **23 (a)** 563 K; **(b)** 248 K; **(c)** 332.2 K **24 (a)** –204°C; **(b)** 1103°C; **(c)** 72.6°C **25** 36.1°C **27** 84.3°C **28** 64°C **31** 26 g **32** 1.5×10^6 J kg^{-1} **36 (a)** 80°C; **(b)** 150°C; **(c)** 1.3×10^5 J; **(d)** 1.3×10^6 J; **(e)** 1×10^7 J kg^{-1}; **(f)** 4.3×10^3 J kg^{-1} K^{-1} **39** 29.3°C **40** 1.9 cm **41** 57 g

Chapter 11

1 920 kPa **2** 50 m^3 **3** 50 cm^3 **4** 2.0 kg **5** 35 cm^3 **6** 180 K **7** 8.8 L **8** 76 cm^3 **9** 5028 balloons **10** 330 kPa **11** 39.8 h **12** 9.7×10^5 Pa **13** 2.1×10^{22} molecules **14** 0.012 moles **15 (a)** 1.0×10^7 Pa; **(b)** 1.0×10^7 Pa **16** 4.8×10^2 m s^{-1} **17** 1.2×10^3 m s^{-1} **18 (a)** 1:1; **(b)** 1: $\sqrt{10}$ **19** 1.6×10^5 Pa **20** 0.90 mm for contraction, 0.75 mm for expansion **21 (a)** 1.5×10^{-2} mm; **(b)** 8.5×10^{-2} mm; **(c)** rings **22** 50°C **23** 4.8 cm **24** 1.1 L **25** 1.7 L **26** 497.8 mL **27** 1.0 m^3 **28** 99.5 h **29** 174 cm Hg **30** 5.2 atm **31 (a)** 1/6 of original volume; **(b)** twice the original **32** 5.9×10^{-2} m^3 **33** 8×10^{23} molecules **34** 175.5°C **35** 4.9×10^{22} molecules **36** 4.8×10^{23} molecules **37** 4.0×10^{-17} J **38** 6.1×10^{-21} J **39** 2.1×10^{-22} J **40** 1999 m **41** 5.5 mm **42** 13.4 g cm^{-3} **43** 17.5×10^{-6} m° C^{-1} **45** 8.3×10^2 J **46** 30°C **47 (a)** 52°C; **(b)** 61°C **48 (a)** 20 m; **(b)** $V_2 = 3.2\ V_1$ **49** 1.1×10^5 Pa **50** 9.5 atm **51** °M = °C + 303

Chapter 12

1 (b) steel, iron, brass, aluminium, and copper **3 (a)** 1.6 kW; **(b)** 5.8×10^6 J **4** 1.3×10^5 J **7** iron **11** 85 W **12** 4.1×10^2 W **13** 9.6×10^6 J **22 (a)** the can of Coke **36** 2.7×10^6 J

Chapter 13

1 1.0 m s^{-1} **2** 6×10^{14} Hz **4** 1.5×10^{3} m s^{-1}, 3.3×10^{-3} s **5** B down, G down, P up, D up, and M up **8 (a)** 20 cm; **(b)** 0.60 s; **(c)** 1.7 Hz **9 (a)** 80 cm; **(b)** 15 cm **(c)** 1.0 Hz **10 (a)** 20 cm; **(b)** 40 cm; **(c)** 2.5×10^{2} cm s^{-1} **11** Speed increases **13 (a)** transverse **14 (a)** transverse; **(b)** longitudinal **17 (a)** 2.0 Hz, 0.50 s, 1.0 m s^{-1}; **(b) (i)** frequency and wavelength, **(ii)** speed of the wave; **(c)** change the tension in the spring **18 (a)** second is heavier than the first; **(b)** transmitted in phase **20 (a)** 20 cm; **(b)** 10 cm **21** 0.30 m s^{-1} **22** 1.1 m **23** 600 m to 10 m **24 (a)** 0.62 m; **(b)** 550 Hz; **(c)** 2.6 m **25 (a)** 4 cm; **(b)** 20 cm; **(c)** 0.10 s; **(d)** 2.0 m s^{-1} **26 (a)** P longitudinal, S transverse, L transverse; **(b)** 300 Hz **27 (a)** A down, B down; **(b)** A to left, B to right **28** 'A' heavier than 'B', 'C' heavier than 'B' **29 (a)** between A and E **(b)** A, C, E, G, I, K; **(c)** B, D, F, H, J; L **(d)** 4 m **30** 0.40 s **31 (a)** λ = 16 cm, f = 0.10 Hz, amplitude = 4 cm, v = 1.6 cm s^{-1}; **(b) (i)** H,C, **(ii)** A,E,F, **(iii)** B,D,G; **(c)** 4.0 cm above where it is now **32 (a)** 4.0 m; **(b)** 40 m s^{-1}; **(c)** A and E, B and F **35 (b)** at an undisturbed position; **(c)** 8.0 cm **36 (a)** 4.0 cm; **(b)** 2.5 Hz **(c)** 2.0 cm; **(d)** 10 cm s^{-1} **37** 333 m s^{-1} **38** $\lambda = \frac{4l}{2n-1}$ *where n = 1, 2, 3, . . .* **39** 36 m **41 (a)** B; **(b)** 1.0 m s^{-1}

Chapter 14

3 0.10 m s^{-1} **4** 0.10 m s^{-1} **5 (a)** 0.05 s; **(b)** 1.25 cm; **(c)** 4 waves; **(d)** 0.625 cm **9 (a)** different depths of water; **(b)** 5.0 Hz; **(c)** 5.0 Hz; **(d)** 15 cm s^{-1} **10** 1.9 cm **11 (a)** Region (i); **(b)** 4:3; **(c)** 4:3; **(d)** 1:1; **(e)** refraction **12 (a)** the dotted line; **(b)** 2.0 cm; **(c) (i)** constructive, **(ii)** destructive, **(iii)** constructive, **(iv)** constructive **15 (a)** 7.5 cm s^{-1}; **(b)** 0.17 s; **(c)** 1.25 cm; **(d)** 6.0 Hz **16** 5 cm s^{-1}, 4.2 Hz **18** 62.5 cm s^{-1}, 25 Hz **19 (a)** 1.3 Hz; **(b)** 4.5 cm **21 (a)** they become circular; **(b)** no change; **(c)** no change; **(d)** no change **23** No change **25 (a)** path difference = 6.0 λ; **(b)** 2.5 λ; **(c)** $n\,\lambda$ **26 (a)** the number of nodal lines will decrease; **(b)** increase in the number of nodal lines; **(c)** decrease in the number of nodal lines **28 (a)** 1:1; **(b)** 6:10 **29** v_d = 80 cm s^{-1}, v_s = 60 cm s^{-1} **31** A **32** C **33** A — nodal line, B — antinodal line, C — nodal line **34 (a)** 10 Hz; **(b)** 2.0 cm; **(d)** 8; **(e)** 'a' is doubled, 'b' is halved, 'd' is doubled **35 (a)** destructive; **(b)** destructive; **(c)** the second order antinodal line; **(d)** the fourth order nodal line **36 (a)** 20 cm s^{-1}; **(b)** 20 cm s^{-1}; **(c)** 2.0 cm; **(d)** destructive interference; **(e)** the first nodal line; **(f)** point X lies on the first antinodal line **37 (b)** Constructive interference occurs when the path difference = (n – 1/2) λ, and destructive when the path difference = $n\,\lambda$

Chapter 15

1 (a) 2.4 cm; **(b)** 6.5 cm; **(c)** 1.6 cm **2** 700 nm **3 (a)** first-order = 0.53 cm, second-order = 1.06 cm; **(b)** first-order = 0.79 cm, second-order = 1.58 cm; **(e)** blue = 440 nm, red = 660 nm **4** 5.8 cm **5 (a)** 1.3 cm; **(b)** 2.6 cm; **(c)** 2.6 cm; **(d)** 1.3 cm; **(e)** central maximum is twice as wide as others **6** 0.20 mm **7 (a)** 22.5 seconds of arc; **(b)** 32.5 seconds of arc; **(c)** Blue light has greater resolving power **8 (a)** 2.6 m; **(b)** 3.9 m **9 (a)** 23.6°; **(b)** 36.9°; **(c)** 5 **10** λ = 532 nm, green **11 (a)** Infra red 1080 nm or Green 540 nm; **(b)** Infra red 720 nm or Blue 432 nm **12** Blue 432 nm **13** 500 nm **14** 7.0×10^{-5} m **15** 1.1×10^{-5} m **18 (a)** 8.7 mm; **(b)** 5.2 cm **19** 2.0×10^{-6} m **20 (a)** 1.5 cm; **(b)** 5.1 mm **21** 667 nm **22 (a)** 0.125 m from P; **(b)** double crest, maximum **23 (b)** 1.4 cm; **(c)** 11.3 mm **24** Green light (568 nm) **25** 480 nm **26** 141 **27 (a) (i)** 3×10^{8} m s^{-1}, **(ii)** 3×10^{8} m s^{-1}, **(iii)** 3×10^{8} m s^{-1}; **(b) (i)** 4.8×10^{14} Hz, **(ii)** 6.4×10^{14} Hz, **(iii)** 3.0×10^{17} Hz; **(c) (i)** 4.8×10^{14} Hz, **(ii)** 6.4×10^{14} Hz, **(iii)** 3.0×10^{17} Hz **29** 2.6 m **30** 75 km **32 (a)** 1.5 cm; **(b) (i)** 2.25 cm, **(ii)** 1.5 cm; **(c)** 4.5 cm **33 (a)** radio waves; **(b)** microwaves; **(c)** infra-red waves; **(d)** X-rays, gamma rays; **(e)** visible light; **(f)** X-rays; **(g)** X-rays; **(h)** microwaves; **(i)** ultraviolet light **34** FM radio **36 (a) (i)** 0 λ, **(ii)** 1/2 λ **(iii)** 2 λ; **(b) (i)** destructive, **(ii)** constructive; **(c)** 440 nm **39** 0.80° **40** 338 nm **41** 674 nm **42** Green (580 nm) Indigo-Violet (414 nm) **43** 4.0×10^{-5} m **45** all false

Chapter 16

4 1 Hz → 7 Hz **5** 8.8×10^{-3} s, 0.34 m **6** Pipe by 0.021 s **7** 336 m s^{-1} **8** 170 m **9** 255 m from you **10** Minimums 1 m apart **11** 333 m s^{-1} **13 (b)** fish are 725 m below **14** 103 kHz **16 (b)** 297 Hz **17** f_o = 340 Hz, third harmonic = 1020 Hz **18** f_o = 1133 Hz, 2 f_o = 2267 Hz, 3 f_o = 3399 Hz, 4 f_o = 4532 Hz **19 (a)** 2550 Hz; **(b)** 5100 Hz; **(c)** 850 Hz **21 (a)** 3.0 Hz; **(b)** 4.0 Hz; **(c)** 6.0 Hz **22** 50 dB **23** 47 dB **24** 3.16×10^{-4} W m^{-2} **26 (a)** 1264 Hz; **(b)** 1142 Hz **27 (a)** 1109 Hz; **(b)** 911 Hz; **(c)** same, 1000 Hz **28** In the direction of motion **29 (a)** 2.4×10^{3} Hz; **(b)** 336 m s^{-1} **30** 3.4 km **32** 0.22 m **33** 840 m **34** 2550 Hz **35** 425 Hz **36 (a)** 340 Hz; **(b)** 0.50 m **37 (a)** 1.16 m **(b)** second overtone = 884 Hz, third overtone = 1179 Hz **38** 343 m s^{-1} **39 (b)** 336 m s^{-1} **40 (d)** 200 Hz, 350 Hz, 400 Hz **41 (a)** 1063 Hz; **(b) (i)** 16 cm from the top, **(ii)** 4 cm from the top, **(iii)** 2.7 cm from the top **43** 439 Hz **44** 248 Hz **45** 437 Hz **46** 484 Hz **47** 8 km h^{-1} **48** 990 m away perpendicular to line of microphones; and 24 m from microphone 1 towards microphone 2

Chapter 17

3 (a) 50°; **(b)** 70°; **(c)** 65° **4** 4 m s^{-1} **7 (a)** Convex mirror; **(b)** concave mirror **8** 23 cm in front of the mirror **9 (a)** 3.3 cm behind the mirror; **(b)** virtual, upright, smaller; **(c)** 1.32 cm **10 (a)** 60 cm in front of the mirror; **(b)** 3:1; **(c)** 3.0 cm; **(d)** real, inverted, magnified **11 (b)** 11 cm behind the mirror; **(c)** 0.88 cm **12 (b)** 2.4 cm behind the mirror; **(c)** 1.2 cm high **13 (a)** u = 30 cm, v = 15 cm; **(b)** u = 15 cm, v = 30 cm **16** 4.0 m **17** Minimum length = 80 cm **19 (a)** diverging; **(b)** diverging; **(c)** parallel; **(d)** converging; **(e)** Parallel; **(f)** Diverging; **(g)** parallel; **(h)** none reflected **20 (b)** real, inverted, magnified; **(c)** 23 cm in front of the mirror; **(d)** 2.3 cm **21** 4 cm **22 (b)** virtual image; **(c)** 8.6 cm behind the mirror **24 (a)** 13.3 cm; **(b)** 10 cm; **(c)** real; **(d)** inverted **30** 60° **31 (a)** concave; **(b)** at the focus; **(c)** use a parabolic dish **35** A, B, D **36 (a)** concave dish; **(b)** at the focus **37 (c)** 2; **(d)** 22.5 cm; **(e)** 15 cm **38** 15 cm **39** 4 cm in front of the convex mirror **40 (a)** u = 10 cm, v = 20 cm behind the mirror; **(b)** u = 30 cm, v = 60 cm in front of the mirror

Chapter 18

2 (a) 1.15; **(b)** 1.67; **(c)** impossible **3 (a)** 2.0×10^8 m s^{-1}; **(b)** 1.25×10^8 m s^{-1}; **(c)** 2.3×10^8 m s^{-1} **4** 1.81 **5 (a)** 1.46 **(b)** 28.7° **(c)** 64.1° **(d)** undefined **6** 1.22 **7 (b)** sin i/sin r = 1.52; **(c)** 1.52; **(d)** 32° **8** 1.14 **9 (a)** 26.5°; **(b)** 24.2°; **(c)** 38°C; **(d)** 1.09 **10 (a)** 1.41; **(b)** 1.14; **(c)** 1.25; **(d)** 1.37 **11** θ_w = 28°, θ_g = 23° **12** (b), (d) **13** True depth = 0.9975 m **14 (a)** no; **(b)** yes; **(c)** no; **(d)** yes; **(e)** yes; **(f)** yes **15** 58.8° **16** 1.2 **18 (a)** 60.5°; **(b)** 1.76×10^8 m s^{-1} **19** 46.4° **20 (a)** towards; **(b)** away; **(c)** towards; **(d)** away; **(e)** away; **(f)** away **21 (a)** 33.6°; **(b)** 2.05×10^8 m s^{-1} **23** 2.6×10^8 m s^{-1} **24 (a)** 1.25; **(b)** 1.67; **(c)** 1.1; **(d)** impossible **26 (a) (i)** 1.69×10^8 m s^{-1}, **(ii)** 2.5×10^8 m s^{-1}, **(iii)** 1.43×10^8 m s^{-1}, **(iv)** 2.11×10^8 m s^{-1}; **(b) (iii)** Highest refractive index **27 (a)** 1.1; **(b)** 43.3° **28** 422 nm **29 (a)** 66.5 cm **30** 88.9° **31** 86.6 m^2 **32** 1.52 **33** 0.67° **34 (a)** 1.19; **(b)** 1.09; **(c)** 1.41; **(d)** impossible **37** 29.6° **39** 1.43 cm **40** Ray passes into prism unrefracted, then retracts at 30.5° into water from upper surface of prism and strikes water surface at 14.5°, refracting into air at 19.5° **41** R, O refract out of right side at different angles; Y, G, B, I, V undergo total internal reflection and head as a single beam towards bottom **42** A spectrum diagonally across page: violet (top left) to red (bottom right) **42 (a)** Colour, don't use plastic, different R.I, degradable plastic

Chapter 19

4 Real inverted image 60 cm from the lens **5** The image is 7.1 m on the object side of the lens **6 (a)** Virtual, upright magnified **(b)** v = –6.67 cm; **(c)** H_i = 4 cm **7 (a)** v = –7.5 cm; **(b)** H_i = 1.25 cm; **(c)** virtual, upright, diminished **8 (a)** virtual, upright, larger, 20 cm on the same side as the object; **(b)** virtual, upright, smaller 4.5 cm on the same side as the object; **(c)** real, inverted, same size, 50 cm on the other side **9 (a)** HM = 2; **(b)** u = 15 cm **10 (a)** M = 0.25; **(b)** u = 40 cm; **(c)** f = 8.0 cm; **(d)** real, inverted, smaller **11** f = 103.7 cm **12 (a)** –4D; **(b)** –0.5D; **(c)** 5D; **(d)** 1D **13 (a)** concave lens f = 20 cm; **(b)** convex lens f = 10 cm; **(c)** convex lens f = 4.0 cm; **(d)** concave lens f = 2.0 cm **14 (a)** convex; **(b)** convex; **(c)** concave; **(d)** concave; **(e)** convex **15 (a) (ii)** 20 cm; **(b) (ii)** 2.25 cm **16 (a)** just inside the focal length; **(b)** H_i = 4 mm **17 (a)** v = 48 cm on the opposite side; **(b)** H_i = 3.7 cm; **(c)** real, inverted, smaller; **(d)** 16.7 cm on the same side as the object **18 (a)** v = –10 cm; **(b)** m = 0.50; **(c)** 5.0 cm **19 (a)** convex; **(b)** virtual, upright, larger; **(c)** –33.3 cm; **(d)** 3.3 mm **20 (a)** 50 mm; **(b)** 56 mm **22** Ray 2, 4 **24 (b)** 25 cm; **(c)** 38 cm; **25 (a)** convex; **(b)** inside the focal length **26** 5.4 cm to the right of the concave lens **27 (a)** two images **(b)** 64.3 cm to the right of the lens, 23.7 cm to the right of the lens **28** f = 20 cm **29** f = 35.5 cm **30** f = 43.8 cm **31 (a)** u = 16 cm from lens; **(b)** u = 24 cm **32** f = 20 cm **33** f = 40 cm

Chapter 20

5 (a) closer **(b)** f_{11} and larger **6 (b)** 2.5 cm **(c)** F4 **7 (a)** 12 cm; **(b)** 17.1 cm; **(c)** cannot be done **8 (a)** 40, 410 cm; **(b)** 2.0 m, 205 cm; **(c)** 5 cm, 305 cm; **(d)** 1.98 m, 99 **10 (a)** 1.25; **(b)** 12.5; **(c)** 0.25; **(d)** 5.0 **16 (a)** cornea and lens; **(b)** ciliary muscles; **(c)** iris; **(d)** rods **20** 40 cm **21 (a)** 1.0 cm; **(b)** 0.50 cm; **(c)** 2.5 cm **23 (a)** convex; **(b)** concave; **(c)** convex; **(d)** convex; **(e)** convex **26 (a)** minimum distance = 30 cm; **(b)** maximum distance = 2.55 m; **(c)** 1.95 m^2 **27** c, d, f **31** 6.67 cm from the lens **33** 50 cm

Chapter 21

1 (a) glass positive, silk negative; **(b)** rubber negative, wool positive; **(c)** gold negative, cat fur positive; **(c)** **4** 4.8×10^{-19} C, the atom has lost three electrons **5** each +2 μC **6** A = +4 μC, B = +1 μC **7** 2.3 N repulsive **8 (a)** repulsive; **(b)** 1.5×10^{-4} N; **(c)** 2.4×10^{-3} N; **(d)** 6.0×10^{-4} N **9** 4.1×10^{-1} N up the page **11** 1.35×10^6 N C^{-1} radially inwards **12** 4.1×10^5 V **13 (a)** 24 V; **(b)** 1.3×10^{-4} J **14 (a)** 1.0×10^4 V m^{-1}; **(b)** 6.0×10^{-2} N upwards; **(c)** 1.2×10^{-3} J **16** Perspex positive, silk negative **17** Excess electrons conducted through the body to earth **18** 3.1×10^{-6} C positive **19** 5.0×10^7 N C^{-1} **20** 1.4×10^{-17} C **21** 7×10^{-9} C **22** 1.8×10^6 V **23** 4.6×10^4 V **24 (a)** 1.2×10^5 V m^{-1}; **(b)** 9.6×10^{-13} N upwards **25** 3000 eV, 4.8×10^{-16} J, 3.2×10^7 m s^{-1} **26 (a)** 1.6×10^{-17} N down page; **(b)** 1.67×10^8 m s^{-2}; **(c)** 8.3×10^{-6} s; **(d)** 5.7×10^{-3} m; **(e)** towards the bottom right **27 (a)** point A; **(b)** zero; **(c)** 200 V; **(d)** 9.0×10^{-7} J; **(e)** 1.8×10^{-6} J **32 (a)** 2.1×10^{-9} s; **(b)** 9.7×10^{-4} m upwards; **(c)** 1.06×10^7 m s^{-1}, angle = 5°

Chapter 22

2 5.3 V **3** 3.1×10^{-4} m s^{-1} **4** 1.5 V **5 (a)** 0.6 A; **(b)** 2.16×10^{3} C **6** 30 mV, it will not be electrocuted **8 (a)** 1.08 Ω; **(b)** 0.72 Ω; **(c)** assuming that conductor B is copper, R = 0.8 Ω **10** Voltmeter 11.8 V, ammeter 0.39 A **11** 0.96 A, current through each 0.48 A **12** Current through R_5 = 1 A, voltage across R_5 is 5 V voltage drop across resistors 1–4 is 5 V and current through each is 0.5 A **13** 144 W; **14 (a)** 1152 Ω; **(b)** 58 Ω; **(c)** 580 Ω **15** 2.2×10^{6} J **16 (a)** 8.9 Ω; **(b)** energy is 18.9 kWh **17 (a)** 4 A; **(b)** 0.25 A; **(c)** 1.1 A **18** 2.2×10^{2} J **19** 8.0×10^{-7} Ω m **21** series **22** The 60 W bulb has a comparatively lower resistance and thus a thicker diameter filament, assuming an equivalent length to the 25 W bulb **23 (a)** R_{tot} = 10 Ω, A = 1.2 A, V = 7.2 V; **(b)** R_{tot} = 15 Ω, A_1 = 1.33 A, A_2 = 0.66 A, V_1 = 6.6 V; **(c)** R_{tot} = 20 Ω, A_1 = 0.9 A, V = 9 V **25** Z = 4 A, Y = 8 A, X = 16 A, V = 64 V, EMF = 160 V **26 (a)** 4 A; **(b)** 60 Ω **27 (a)** 20 bulbs in series; **(b)** 20 W; **(c)** 12 V; **(d)** 83 mA, R = 145 Ω **30 (a)** A is the ohmic resistor; **(b)** 14.5 V; **(c)** 15 V; **(d)** the same **35** 5.1 hours **36** 1.25 Ω **37 (a)** zero potential difference between the opposite ends of the bridge; **(c)** R_x = 1.0 kΩ **38 (a)** 92 Ω; **(b)** 45 V across the 60 Ω resistor **39** R = 232 Ω or 43 Ω

Chapter 23

2 Adjust vertical amplifier to a smaller value in volts/division and decrease the timebase period **3** V_{PP} = 44 V **4** P = 30 W, Yellow–purple–brown **6** Plastic film or greencaps, electrolytics, ceramic capacitors **7** τ = 12 µs **9** time = 12.5 ms; I = 2.4 A **11** V_P = 10.6 V **13 (a)** 20 V; **(b)** 40 V; **(c)** 0.0 V; **(d)** 14.1 V; **(e)** 25 Hz **14 (a)** 5.6 A; **(b)** 3.96 A; **(c)** 60 Hz **16** 75 V, I = 13.3 mA **17** V_1 = 4.1 V, V_2 = 5.9 V, I = 72 mA **20** τ = 47 s, full charge after 141 s, $W = 1.9 \times 10^{-2}$ J **22** 3.2 W **23** V_o = 6.1 V, V_{av} = 3.9 V **24** Decreasing the load resistance increases the current drawn from the supply, with an increase in ripple voltage or hum **29 (a)** $\tau = 2 \times 10^{-2}$ s; **(b)** $\tau = 1 \times 10^{-2}$ s **30 (a)** $I = I_L + I_Z$; **(b)** $V_{in} = V_R + V_Z$; **(c)** $R = \dfrac{V_{in} - V_Z}{I_L + I_Z}$; **(d)** P = 57 mW; **(e)** I_L = 4 mA **(f)** R = 470 Ω preferred **31 (a)** 1.4×10^{-9} C and 5.6×10^{-9} C; **(b)** 2.8×10^{2} V; **(c)** 2.4×10^{-8} J

Chapter 24

3 I_C = 3 mA, I_E = 3.015 mA **6** I_B = 25 µA, V_C = 1.4 V **7** β = 100 **9** Z_{in} = 10 kΩ **11** Square wave **13** Binary levels are two state; ON = high (5 V), OFF = low (0 V) **15** f_0 = 200 Hz **16** phototransistor — input transducer, loudspeaker — output transducer **20** β = 86, or β = 116 **22** A_V = 94 **25 (a)** I_C = 100 mA; **(b)** R_C = 30 Ω; **(c)** R_B = 5.2 kΩ nearest preferred **26 (a)** R_B = 280 Ω; **(b)** 0.4 mW in R_B, 0.13 W in R_L; **(c)** 5.4 V; **(d)** 0.7 V **27 (b)** I_B = 7.15 µA, I_C = 0.86 mA, V_{CE} = 1.4 V

Chapter 25

1 A substance that can be magnetised. Yes it does! **2** A magnetic pole is permanent, an induced magnetic pole is temporary **3** An experiment based on repulsion **4** The way in which they are influenced by magnets **5** Development of new magnetic materials with greater strength **7** Magnetic flux is the total number of field lines passing through an area, whereas magnetic flux density is the magnetic flux per unit area **8** 2.2 T **10** Declination is the angle between the Earth's magnetic axis and it's geographical axis. Inclination or dip is the angle of the field lines to the horizontal **11 (a)** 7.3×10^{-6} T; **(b)** 3.3×10^{-5} T, direction for both depends on position around the wire being considered. Use the screw rule **12** 0.75 T **13** 75 A current from A to B **14** 4×10^{-5} T up, 1.6×10^{-4} T down **15** 1.4×10^{-4} N to the right **16** 0.05 N up the page **17 (a)** down the page; **(b)** to the left **18 (a)** side AB downwards, side DC upwards; **(b)** to allow coil to freely rotate; **(c)** 0.18 N **19 (a)** 3.15×10^{-14} N; **(b)** acceleration = 5.6×10^{12} m s^{-2} **20 (a)** X and Y positive, Z negative; **(b)** particle Y has the greatest mass as it's radius of curvature is greatest **23** 1.1×10^{-5} Wb **24 (a)** A: N, B: S; **(b)** A; N, B: S; **(c)** both A and B not magnetised **25** Force is attractive, 1.2×10^{-4} N m^{-1} **26** 2.0×10^{-2} N downwards **27** 7.5 A, towards the east **28** 1.3 mT into page **31** Field strength is too small to affect the watch **33 (a)** Magnetic field directed into the page; **(b)** 3.2×10^{-17} J; **(c)** $m = \dfrac{qB^2r^2}{2V}$; **(d)** 1.0×10^{-30} kg **34** Current direction is Y to X, 0.98 A **35 (a)** 67 A; **(b)** 5.4 N m **36 (a)** ${}^{4}_{2}He^{2+}$: b, ${}^{4}_{2}He^{+}$: d, ${}^{3}_{2}He^{2+}$: a, ${}^{3}_{2}He^{+}$: c; **(b)** in order left to right, ${}^{200}_{80}Hg^{2+}$, ${}^{204}_{80}Hg^{2+}$, ${}^{200}_{80}Hg^{+}$, ${}^{204}_{80}Hg^{+}$, ${}^{400}_{160}Hg_2^{+}$, ${}^{404}_{160}Hg_2^{+}$, ${}^{408}_{160}Hg_2^{+}$

Chapter 26

2 (a) 0.24 V; **(b)** 0.2 V **3 (a)** $V_{AB} = V_{DC}$ = 0 V, $V_{AD} = V_{BC}$ = 0.06 V; **(b)** no current will flow as V_{AD} opposes V_{BC} **6** A very large output AC voltage could be induced even for a small input voltage **8** 1600 µV **9** Step-up, turns ratio is 52 **10** 140 V peak **11** Losses due to lower voltage distribution **12 (a)** appliances used to heat water and cook breakfast meals; **(b)** use of artificial heating in homes; **(c)** appliances used to cook evening meals as well as general heating **13** At 11 kV, power loss is 3.6×10^{5} W, at 66 kV, 9.9×10^{3} W only **14** 2.4 V **15** 90 V **16** 267 V **17** Because without it, the law of conservation of energy would be violated **19** 53 turns **20** Because a changing magnetic flux is needed for induction **23** The magnet will, at first, be attracted downwards into the right solenoid and then pushed upwards again **24** 240 V_{RMS} @ 50 Hz **26** Factors: input AC voltage, turns ratio, laminations;

energy appears as heat **27** 40 mA **28 (b)** 12 mV **29** Induced current will flow from right to left through the ammeter and then the solenoid **30 (a)** 5.1 kW; **(b)** 218 V at hospital, hence could not use satisfactorily; **(c)** voltage would drop considerably; **(d)** voltage loss about 1.0 V only **31** 10 Hz.

Chapter 27

2 (a) 8080 V m^{-1}; **(b)** 1.274×10^{-18} C; **(c)** 8 e$^-$ **5** electrometer **6** filament **9** False–neutron not discovered until 1930. **12** ${}^{12}_{6}C$, ${}^{14}_{6}C$ **13** ${}^{3}_{2}He$ (1n, 2p, 2e); ${}^{4}_{2}He$ (2n, 2p, 2e) **14** Neutrons are neutral and aren't repelled by electron cloud or positive nucleus **15** protons, neutrons: **(a)** 1,1; **(b)** 6,6; **(c)** 8,9; **(d)** 11,12; **(e)** 16,16; **(f)** 47,60; **(g)** 53,74; **(h)** 92,146 **16** 28.103 **17 (a)** 8.48 MeV, 2.83 MeV/nucleon; **(b)** 7.71 MeV, 2.57 MeV/nucleon; **(c)** 104.4 MeV, 7.46 MeV; **(d)** 127.6 MeV, 7.97 MeV **18** 341.324 MeV **19 (a)** 5.5×10^{3} V m^{-1}; **(b)** 1.92×10^{-18} C, 12 e$^-$ **20 (a)** 82, 125; **(b)** 17, 18; **(c)** 7, 8; **(d)** 85, 130; **(e)** 83, 133 **22 (a)** ${}^{40}_{20}Ca$, ${}^{42}_{20}Ca$, ${}^{43}_{20}Ca$, ${}^{45}_{20}Ca$; **(b) (i)** 20, **(ii)** 40; **(i)** 22, **(ii)** 42; **(i)** 23, **(ii)** 43; **(i)** 25, **(ii)** 45 **23 (a) (i)** 0.320 802 u, **(ii)** 1.915 055 u, **(iii)** 1.034 425 u, **(iv)** 0.042 131 u; **(b)** 8.5 MeV/nucleon, 7.58 MeV/nucleon, 8.5 MeV/nucleon, 5.6 MeV/nucleon **25 (a) (i)** to produce e$^-$, **(ii)** anode is +ve, **(b) (i)** more e$^-$ produced, **(ii)** faster acceleration **26** 2.44×10^{-15} kg **27** 22 **28** D **29** F

Chapter 28

1 The air is ionised and the electroscope attracts opposite charge from the air **3 (a)** 88, 138; **(b)** 1, 0; **(c)** 93, 146 **4 (a)** radium; **(b)** hydrogen; **(c)** Bk; **(d)** Sr **5 (a)** ${}^{214}_{84}Po$; **(b)** ${}^{239}_{92}U$; **(c)** ${}^{4}_{2}He$; **(d)** ${}^{45}_{21}Sc$; **(e)** ${}^{58}_{28}Ni$; **(f)** ${}^{230}_{92}U$ **6 (a)** ${}^{32}_{16}S$; **(b)** ${}^{0}_{-1}e$; **(c)** ${}^{22}_{10}Ne$; **(d)** ${}^{0}_{-1}e$; **(e)** ${}^{1}_{0}n$ **7 (a)** ${}^{210}_{83}Bi$; **(b)** ${}^{214}_{83}Bi$; **(c)** ${}^{222}_{86}Rn$; **(d)** ${}^{210}_{84}Po$ **8 (a)** ${}^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$; **(b)** ${}^{24}_{11}Na \rightarrow {}^{0}_{-1}e + {}^{24}_{12}Mg$ **(c)** ${}^{32}_{15}P \rightarrow {}^{0}_{-1}e + {}^{32}_{16}S$ **9 (a)** ${}^{23}_{11}Na \rightarrow {}^{0}_{-1}e + {}^{22}_{10}Ne$; **(b)** ${}^{18}_{9}F \rightarrow {}^{0}_{+1}e + {}^{18}_{8}O$; **(c)** ${}^{19}_{10}Ne \rightarrow {}^{0}_{+1}e + {}^{19}_{9}F$ **(d)** ${}^{199}_{82}Pb \rightarrow {}^{0}_{+1}e + {}^{199}_{81}Tl$ **10 (a)** 0.02235 s^{-1}, 1.34 min^{-1}; **(b) (i)** 5 g, **(ii)** 1.25g, **(iii)** 3×10^{-5} g **11 (a)** 89.7 min **(b)** 34.46 min **12 (a)** 0.0693 min^{-1} (or 0.00115 s^{-1}) **(b)** 8×10^{13} Bq **(c) (i)** 1.245×10^{12} Bq **(ii)** 1165 Bq **(d)** 7.7 hours **13** 2.62 minutes **14 (b)** 4.38×10^{-3} min^{-1}; **(c)** 158 minutes **15** 11 400 y **16** 686 years old, hence 1302 AD; previously believed to be genuine and hence should have a date of about 32 AD when Jesus died **17 (a)** 2.03×10^{-11} J; **(b)** 5.21×10^{13} J/kg **18 (a)** 2.82×10^{-12} J; **(b)** 5.24×10^{-13} J; **(c)** 3.02×10^{-12} J. Most energy comes from reaction (c) **24 (a)** U; **(b)** H; **(c)** Ra; **(d)** P **25 (a)** ${}^{24}_{12}Mg$; **(b)** ${}^{22}_{10}Ne$; **(c)** ${}^{206}_{82}Pb$; **(d)** ${}^{32}_{16}S$ **26 (a)** ${}^{0}_{-1}e$; **(b)** ${}^{222}_{86}Rn$ **27 (a)** ${}^{b}_{a}X \rightarrow {}^{4}_{2}He + {}^{b-4}_{a-2}Y$ **(b)** ${}^{b-4}_{a-2}Y \rightarrow {}^{0}_{-1}e + {}^{b-4}_{a-1}Z$ **28 (a)** ${}^{1}_{0}n$; **(b)** ${}^{24}_{11}Na$; **(c)** ${}^{25}_{12}Mg$; **(d)** ${}^{39}_{19}K$; **(e)** ${}^{27}_{13}Al$; **(f)** ${}^{9}_{4}Be$ **29** ${}^{96}_{38}Sr \rightarrow 4{}^{0}_{-1}e + {}^{96}_{42}Mo$ **30 (a)** ${}^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$; **(b)** 0.000 381 u = 6.32×10^{-31} kg; **(c)** 5.69×10^{-14} J **31 (a)** ${}^{116}_{49}In \rightarrow {}^{0}_{-1}e + {}^{116}_{50}Sn$; **(b)** 5.297×10^{-30} kg; **(c)** 4.767×10^{-13} J **32** No, need something that exchanges carbon dioxide **33** 34 670 y **34** 13.8 million years **35 (a)** 353.5 GBq; **(b)** 9.95 half-lives, **36 (a)** 148 days; **(b)** 285 days **37 (a)** 0.0859 days^{-1}; **(b)** 5.0×10^{16} atoms; **(c)** 126 days **38** emit as β **40** 1.00 min **42 (a)** 49.6 y; **(b)** 15 **43 (a)** 4.123×10^{-12} J; **(b)** 6.16×10^{14} J **44 (i)** 8.145×10^{13} J/kg; **(ii)** 5.72×10^{14} J/kg, reaction **(ii)** produces more energy per kilogram; **(b)** reaction i is fission, ii is fusion **45** $X_1 = {}^{13}_{7}N$; $X_2 = {}^{13}_{6}C$; $X_3 = {}^{14}_{7}N$; $X_4 = {}^{15}_{8}O$; $X_5 = {}^{15}_{7}N$; $X_6 = {}^{12}_{6}C$; **(b)** sum: $4{}^{1}_{1}p \rightarrow 2{}^{0}_{+1}e + {}^{4}_{2}He$ **46 (a)** 4.3333×10^{6} kg/s; **(b)** 7.3×10^{15} y **47** 8.97×10^{13} J; 1.8 million times greater **48 (a)** 172 800 kg; **(b)** 4.84×10^{14} kg **49** Half life = 2.5 days **50** Make alloy of Au-198 with Al and make a saucepan. Use this for cooking and scan brain of patient **51** Number of particles in 10 s = 3.7×10^{14}; energy = 74 J; dose = 0.74 J; absorbed dose = 0.011 Gy **52** ${}^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{92}U$ ${}^{239}_{92}U \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$ ${}^{239}_{93}U \rightarrow {}^{239}_{94}Pu + {}^{0}_{-1}e$.

Chapter 29

1 Electromagnetic force acts on electrons, Strong and weak nuclear forces act on nucleons, whereas the gravitational force acts on all matter. Gravity has the biggest range and the weak nuclear force has the smallest range **2** E = 2.85×10^{-19} J, λ = 697 nm (red) **3** Violet photons have greater energy and shorter wavelengths than red photons **4** $W = 3.3 \times 10^{-19}$ J, $v = 6.7 \times 10^{5}$ m s^{-1} **5** 253 nm ultraviolet photons **8** Lyman series of ultraviolet photons: 122 nm, 103 nm, 98 nm **10** 760 nm **11** 9.7×10^{-10} m **12** An electron's position around the nucleus can only be stated with a certain probability **13** Under conditions applying to the sub-atomic domain **17** 3.62×10^{-19} J = 2.3 eV **18 (a)** 500 nm (green); **(b)** 3.98×10^{-19} J; **(c)** 1.66×10^{-19} J; **(d)** 2.32×10^{-19} J; **(e)** 7.1×10^{5} m s^{-1} **19** 3.0×10^{-12} m, order of magnitude equivalent **20 (a)** 2.03×10^{-18} J; **(b)** 2.17×10^{-18} J; **(c)** 3.14×10^{15} Hz **21** 1.64×10^{-13} J **22 (a)** leptons, β decay; **(b)** nucleons, hadrons; **(c)** all matter **28** 1.69×10^{-27} kg **29** x = 0.6 eV, y = 0.8 eV **30** 4.5×10^{-11} m **31 (a)** 8.16×10^{-19} J; **(b)** 3.36×10^{-19} J and 4.96×10^{-19} J; **(c)** 6.2×10^{-20} J

Chapter 30

1 0.54*c* **2** 7.8×10^{-9} s **3 (a)** 0.06*c*; **(b)** 2.85×10^{8} m s^{-1}; **(c)** 2.8×10^{14} km; **(d)** 317 ly **4** still 40.0 m **5** 0.97*c* **6 (a)** 5.44 y; **(b)** 3.26 y; **(c)** 2.61 ly **7 (a)** 0.40*c*; **(b)** 0.909*c* **8** 0.54*c* **9** 0.96*c* **10** 4.9×10^{-28} kg **11** 0.0003 kg **12** 7.1×10^{-16} J **13** 3.3×10^{-13} J **14** on the car **15** 1.0 *c* **16** 0.87*c* **17 (a)** 0.867*c*; **(b)** 1.1×10^{-7} s **18** Not perceptibly **19** 181.4 m **20** 0.866*c* **21** 14.4 ly **22 (a)** 0.447*c*; **(b)** 0.966*c* **23** *c* **24** 0.866*c* **25 (a)** 0.999 999 218*c*; **(b)** 1.875 m **26 (a)** 9.0×10^{7} J; **(b)** 9.0×10^{5} kg **27** To you nothing would change. To observers on Earth, mass would increase and any length in the direction of motion would decrease **28 (a)**, **(b)**, **(c)**, **(g)** dependent; **(d)**, **(e)**, **(f)** independent **29** yes **30** 0.0153 m **31 (a)** 8.92 m long, no change to height; **(b)** 13 s; **(c)** v is the same (0.760*c*) **32** 0.8*c* **33 (a)** 9.336 ly; **(b)** 21.0 years **34 (a)** 5.9×10^{19}J; **(b)** 4.7% **35** for example: 70.7 kg at 0.9999 *c* **36** his car 5.90 m; your car 6.25 m **37 (a)** 5.28 y; **(b)** 3.168 y; **(c)** 2.535 ly 39 **(a)** 0.51 MeV **(b)** 1.64×10^{-13}J **(c)** 0.94c

Chapter 31

1 (a) $1.6 \times 10^3\ \Omega$; **(b)** $3.1 \times 10^3\ \Omega$; **(c)** 3.2 mA; **(d)** 31^0 **2 (a)** 356 Hz; **(b)** 0.33 A; **(c)** V_R = 50 V, V_C = +74 V, V_L = –74 V; **(d)** 16.5 W; **(e)** 1.5 **3** 560 Ω nearest, input voltage = 12 V **4** voltage divider bias **5** R_E = 100 Ω, R_C = 360 Ω, R_1 = 22 kΩ, R_2 = 3.9 kΩ, C_1 = 1 μF, C_2 = 47 μF **8 (a)** OR; **(b)** AND; **(c)** NOR; **(d)** 3 input AND; **(e)** NOT **11 (a)** 660 Ω; **(b)** 810 Ω; **(c)** 7.4 mA; **(d)** 55° **13** R_E = 130 Ω, R_C = 560 Ω, R_1 = 33 kΩ, R_2 = 5.6 kΩ, C_1 = 10 uF, C_2 = 47 uF A_V = 50 **15 (b)** I_P = 12 mA **17** Component listing is LDR, LED, single pole switch, variable resistor, inverter gate, OR gate, resistor, connecting wires **18 (a)** Z_{AB} = 42.1 Ω; **(b)** Z = 53 Ω; **(c)** I_{RMS} = 0.1 A; **(d)** V_{AB} = 4.2 V

Chapter 32

1 1.85×10^6 m^2 **6** 5×10^5 J, at 50° reduces to 3.8×10^5 J **7** 330 W m^{-2}. The northern hemisphere is in summer during August **8** Photothermal devices convert solar energy to heat (solar heater) whereas a photovoltaic device converts solar energy directly to electricity (solar cell) **11** Photovoltaic action generates its own EMF and does not require a vacuum environment as does the photoelectric effect **12** 1.1 kW. Actual power output depends primarily on the solar radiation flux change with time, as controlled by such variables as cloud cover **15 (a)** heat losses; **(b)** to obtain maximum power to weight ratio; **(c)** ratio of energy output to energy input is 0.95; **(d)** 18.5 A **18** Open circuit voltage (no load) is 20 V DC, whereas at maximum power transfer the output voltage is 12 V DC **19 (a)** Combined reading for Friday is incorrect **20 (a)** 228 MJ; **(b)** 148 MJ; **(c)** 133 MJ **21 (a)** 34.3 MJ; **(b)** 25°C **22** Bracket length is 250 mm

Chapter 33

2 $\lambda = 5.2 \times 10^{-12}$ m **3** Magnetic deflecting coils **5** Roentgen, Ruska, Rohrer, Donald, Hounsfield and Damadian **6** Diagnostic ultrasound; fatty tissue images dark grey while lymphoma images light grey **8** Radioisotopes: ^{99m}Tc, gamma emitter, reactor; ^{201}Tl, X and gamma emitter, cyclotron; ^{18}F, gamma emitter, cyclotron **9** 1.8 mSv, subjected to gamma radiation that is about the same as the yearly background dose **10** It is probably a metallic object **12** MRI depends on RF radiation emitted by hydrogen **15** Highest dosage — lumbar spine film, lowest dosage — chest AP film **17** Alpha particle's mass is considerably higher, hence more damage ability