Question Number	Answer	Notes	Mark
1(a)	N on left pole and S on right pole;	allow north for N and south for S ignore attempt at labelling poles on far sides of magnets	**1**

Question Number	Answer	Notes	Mark
1(b)	idea that steel is a hard **magnetic** material;	allow steel keeps its magnetism/magnetic field allow steel is hard to demagnetise	**1**

Question Number	Answer	Notes	Mark
1(c)	any two from: MP1. (field) lines are straight; MP2. (field) lines are evenly spaced; MP3. (field) lines are parallel;	allow equivalent statements	**2**

Question Number	Answer	Notes	Mark
1(d)(i)	idea that wire cuts magnetic field lines;	allow wire passes through field lines ignore wire interacting with field lines	**1**

Question Number	Answer	Notes	Mark
1(d)(ii)	any two from: MP1. move wire faster; MP2. move magnets closer together; MP3. use stronger magnets; MP4. turn wire into a coil;	 ignore “bigger” magnets ignore more turns on the coil	**2**

Question Number	Answer	Notes	Mark
2(a)	(nuclei with) the same number of protons; (but) different number of neutrons;	allow same atomic number / same element allow different nucleon / mass number /atomic mass	**2**

Question Number	Answer	Mark
2(b)	The only correct answer is **A** (82); *B is incorrect because this is the number of neutrons* *C is incorrect because this is the number of nucleons* *D is incorrect because this is double the proton number + nucleon number*	**1**

Question Number	Answer	Notes	Mark
2(c)(i)	evidence of 3 half-lives; correct evaluation; e.g. 240 ÷ 23 = 30 66 ÷ 3 = 22 (years)	seen anywhere in working	**2**

Question Number	Answer	Notes	Mark
2(c)(ii)	correct atomic and mass numbers used for alpha particle; correct evaluation of number of beta particles; e.g. atomic number of alpha = 2, mass number = 4 (therefore) 2 beta decays (to get back to 82) $^{210}_{82}Pb \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}\alpha + 2\,{}^{0}_{-1}\beta$	seen anywhere in working	**2**

Question Number	Answer	Mark
3(a)(i)	The only correct answer is **C** (white); *A is incorrect because its temperature is the second lowest* *B is incorrect because its temperature is the lowest* *D is incorrect because its temperature is the second highest*	**1**

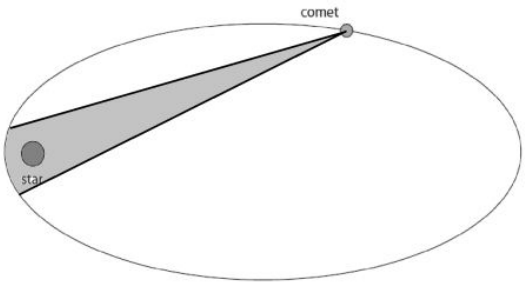
Question Number	Answer	Mark
3(a)(ii)	The only correct answer is **C** (supernova); *A is incorrect because the main sequence is not at the end of the stars life* *B is incorrect because a protostar is not at the end of the stars life* *D is incorrect because the star is too massive enough to form a white dwarf*	**1**

Question Number	Answer	Mark
3(b)(i)	(nuclear) fusion;	**1**

Question Number	Answer	Notes	Mark
3(b)(ii)	Sun becomes a red giant; (then) a white dwarf;	 allow planetary nebula reject mention of supernova, neutron star or black hole for this mark	**2**

Question Number	Answer	Notes	Mark
3(c)(i)	(mass =) 5 x 10^{29} (kg);	Allow 5.3 x 10^{29}, 5.2 x 10^{29}, 5.25 x 10^{29} (kg)	**1**

Question Number	Answer	Notes	Mark
3(c)(ii)	evaluation of time; answer to 1 significant figure; e.g. (time = 5.25 x 10^{29} / 9 x 10^{19} =) 5.8 x 10^{9} (years) (time =) 6 x 10^{9} (years)	allow ecf from (c)(i) allow 5.56 x 10^{9} (years) allow 6 000 000 000, 6 billion years	**2**

Question Number	Answer	Notes	Mark
3(d)	arrow pointing from the comet to the star; force labelled ‘gravitational’;  	accept any arrow pointing from comet to star within shaded area ignore starting position of arrow allow ‘gravity’ or ‘weight’	**2**

Question Number	Answer	Mark
4(a)	arrows drawn on sides WX and YZ one up, one down; 2 arrow on WX down, arrow on YZ up;	**2**

Question Number	Answer	Notes	Mark
4(b)	any four from: MP1. magnetic field around the wire; MP2. interaction between this field and the field from the magnet; MP3. (produces) a force on wire / coil; MP4. forces on opposite sides of the coil are in opposite directions; MP5. coil starts to rotate;	 allow magnetic field overlap also scores MP3 allow coil rotates / turns / spins	**4**

Question Number	Answer	Notes	Mark
4(c)	force (on wire/coil) increases; (therefore) rotation speed is greater;	allow strong magnetic field around wire/coil allow coil spins faster	**2**

Question Number	Answer	Notes	Mark
5(a)	any five from MP1-MP7: apparatus: MP1. method of creating thin beam of light; MP2. protractor; method: MP3. draw round the block; MP4. shine light into the block at an angle to the normal; MP5. mark incident and refracted rays; MP6. measure angles from the normal; MP7. repeat for different angles of incidence; PLUS MP8. graph of sin(i) and sin(r) with n found from gradient	allow marking points from diagram e.g. laser, ray box etc. ignore torch however expressed allow simple use of n=sin(i)/sin(r)	**6**

Question Number	Answer	Mark
5(b)	optical fibres; named prismatic use e.g. cats eye reflector, binoculars, periscope etc;	**2**

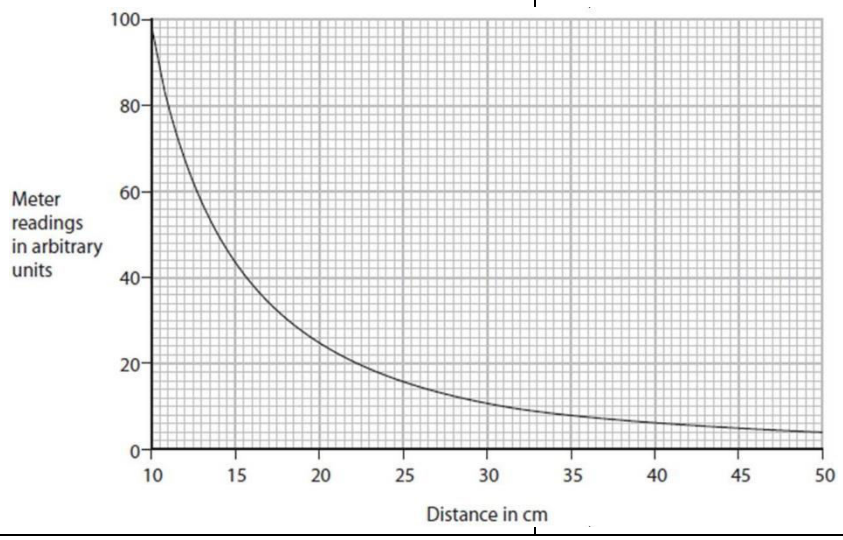
Question Number	Answer	Mark
6(a)(i)	amplitude in the range of 0.8 – 0.9 (cm);	**1**

Question Number	Answer	Mark
6(a)(ii)	wavelength in the range 3.9 – 4.0 (cm);	**1**

Question Number	Answer	Notes	Mark
6(b)(i)	radio (waves);	allow radio frequency reject radioactive (waves), radiation (waves)	**1**

Question Number	Answer	Notes	Mark
6(b)(ii)	substitution; rearrangement; evaluation; e.g. 3.0×10^8 = frequency x 0.027 (frequency =) $3.0 \times 10^8 / 0.027$ (frequency =) 1.1×10^{10} (Hz)	allow wavelength substitution in cm or m -1 if POT error allow 1.11…x 10^{10} (Hz)	**3**

Question Number	Answer	Mark
6(c)(i)	68;	**1**

Question Number	Answer	Notes	Mark
6(c)(ii)	relationship is not inversely proportional; correct calculation of constant for one pair of readings correct calculation of constant for second pair of readings; statement to show meter reading × distance is not constant;  	allow conclusion is incorrect	**4**

Question Number	Answer	Notes	Mark
7(a)(i)	rearrangement OR substitution into given formula; evaluation; e.g. $V_2 = p_1 \times V_1 / p_2$ OR $120 \times 92 = 64 \times V_2$ (volume =) 170 (m^3)	 allow 172, 173, 172.5	**2**

Question Number	Answer	Notes	Mark
7(a)(ii)	constant temperature / amount of air / mass of air;	however expressed e.g. number of particles constant	**1**

Question Number	Answer	Notes	Mark
7(b)(i)	any three from: MP1. (reduction in temperature) reduces speed/KE of particles; MP2. idea of fewer collisions with walls per unit time; MP3. idea of each collision with wall being less 'hard'; MP4. force (per unit area) on the container decreases;	 allow particles collide with walls less often	**3**

Question Number	Answer	Notes	Mark
7(b)(ii)	substitution into given formula; rearrangement; evaluation; e.g. $120 / 290 = 64 / T_2$ $T_2 = (64 \times 290) / 120$ (temperature =) 150 (K)	 allow 155, 154.6… (K)	**3**