AREA 1 – ELECTRIC POWER

Q	Marks	Answer	Solution
1	2	**A**	The two halves will maintain the N at the left end and S at the right end and the two in-between poles will be opposite to each of these within each half magnet → N S / N S ∴ A
2	2	**34 V**	$V_{peak} = V_{RMS} \times \sqrt{2} = 12 \times \sqrt{2} = 16.97$ $V_{p\text{-}p} = 2 \times V_{peak} = 2 \times 16.97 = 33.9$ or 34 V
3	2	**36 W**	P = V I (use all RMS values) P = 12 × 3 = 36 W
4	2	**20 or 20 : 1**	The primary is connected to the 240 V supply. The secondary is connected to the 12 V garden lights. Turns ratio follows voltage ratio → 240 : 12 or 20 : 1 or $\frac{20}{1}$ or just 20
5	2	**0.15 A**	Current ratio is inverse of turns or voltage ratio → 1 : 20 = $I_{primary}$: 3 ∴ $I_{primary} = 3 \div 20 = 0.15$ A or 150 mA OR $P_{primary} = P_{secondary} = 36$ W = 240 × $I_{primary}$ ∴ $I_{primary} = 36 \div 240 = 0.15$ A
6	2	Correctly drawn circuit has all 6 lights **in parallel**.	
7	2	**0.5 A**	6 lights in parallel each have 1/6th of the total current → 3 ÷ 6 = 0.5 A
8	2	This is because some of the voltage is lost along the long connecting wires and ∴ less than 12 V is available for these furthest lights.	
9	2	Using the right hand slap rule, the thumb points from X-Y, the fingers point from N-S, and the palm gives the force as up. An arrow should be drawn with its base **on the wire**, pointing vertically up.	
10	2	**2.5×10^{-4} Wb**	$\phi = BA = 5 \times 10^{-3} \times 0.5 \times 0.1 = 2.5 \times 10^{-4}$ Wb (note: area must be in m^2 so length and width must be in metres)
11	2	**0.01 N**	$F = B I L = 5 \times 10^{-3} \times 4.0 \times 0.5 = 0.01$ or 1×10^{-2} N
12	2	**1.2×10^{-3} V**	emf = B L v = $5 \times 10^{-5} \times 1.2 \times 20 = 0.0012$ or 1.2×10^{-3} V

Q	Marks	Answer	Solution
13	2	**B**	There is zero flux through the loop before it passes into the field, then the flux increases and reaches and remains a maximum while the loop is wholely within the field, then it reduces to zero again when the loop has passed completely out of the field. This is shown in graph B.
14	2	**2×10^{-5} V**	The flux reduces from a maximum to zero in 0.5 seconds as the loop moves out of the field (2 cm at 4 cm/s). $\text{emf} = \frac{n\Delta\phi}{\Delta t} = \frac{1 \times 0.025 \times 0.02 \times 0.02}{0.5} = 2 \times 10^{-5}$ V or 20 μV
15	2	**D**	With a split ring commutator, the generator is a DC generator and the output on the CRO screen will have only positive (or negative, not shown) sinusoidal voltage like graph D.
16	2	**B**	With slip rings, the generator is an AC generator and the output on the CRO screen will have a positive and negative sinusoidal voltage like graph B.
17	2	The soft iron core carries the magnetic field produced by Coil 1 to the position of Coil 2.	
18	2	**0 A**	No current is produced if DC is supplied to coil 1. (To operate properly a transformer needs a changing voltage in the primary coil to produce a changing flux hence inducing an alternating voltage and current in the secondary coil.)

AREA 2 – INTERACTIONS OF LIGHT AND MATTER

Q	Marks	Answer	Solution
1	2	The **wave** model of light could best explain diffraction. Diffraction is the spreading out of a wave as it passes through a gap (slit, opening) OR as it passes the edge of an obstacle. Particles cannot explain this spreading phenomenon. OR a labelled diagram showing wave diffraction.	
2	2	Photoemission is the production of a photon of light when electrons are accelerated (and decelerated).	
3	2	The pattern of bright and dark lines are produced by the constructive and destructive interference of the light coming through the two slits.	
4	2	**2.21×10^{-6} m**	pd = (n – ½) λ for a dark line, and n = 4. pd = $3.5 \times 632 \times 10^{-9} = 2.21 \times 10^{-6}$ m
5	2	**D**	The spacing of the pattern is increased by increasing L or λ or by decreasing the spacing between the slits or the frequency of the light ∴ A, B and C all work giving D as the correct answer.
6	2	**1.66×10^{-23} kgms^{-1}**	$p = h / \lambda = 6.63 \times 10^{-34} \div (40 \times 10^{-12}) = 1.66 \times 10^{-23}$ kgms^{-1}
7	2	**31.1 keV**	$E = hc / \lambda$ and $h / \lambda = p$ ∴ $E = pc$ $= 1.66 \times 10^{-23} \times 3 \times 10^{8} = 4.98 \times 10^{-15}$ J $= 4.98 \times 10^{-15} \div (1.6 \times 10^{-19})$ eV = 31125 eV or 31.1 keV OR $E = hc / \lambda$ $= 4.14 \times 10^{-15} \times 3 \times 10^{8} \div (40 \times 10^{-12}) = 31050$ eV or 31.1 keV
8	2	**A**	The de Broglie wavelength of the electrons is similar to the wavelength of the X-rays ∴ A. They do not have the same energy, or speed or frequency.
9	2	**2.1 eV**	$W = E_{light} - E_{k\,max} = hf - E_{k\,max} = 4.14 \times 10^{-15} \times 7.3 \times 10^{14} - 0.9$ W = 3.0 – 0.9 = 2.1 eV
10	2	**5.1×10^{14} Hz**	$W = h f_0 \rightarrow f_0 = W / h$ $f_0 = 2.1 \div (4.14 \times 10^{-15}) = 5.1 \times 10^{14}$ Hz

Q	Marks	Answer	Solution
11	2	**2.6×10^{16} electrons per second**	Each photon in the incident light beam releases one photoelectron from the metal which then constitutes the 4.2 mA photocurrent. The number of electrons per second in the current equates to the minimum number of photons per second in the light beam: 4.2 mA is a flow of 4.2×10^{-3} C of charge per second which is $4.2 \times 10^{-3} \div (1.6 \times 10^{-19})$ electrons per second or 2.6×10^{16} electrons per second, liberated by 2.6×10^{16} photons per second.
12	2	Nothing will happen with this new frequency light as it is below the threshold frequency of 5.1×10^{14} Hz.	
13	2	**3×10^{8} ms^{-1}**	All light travels at the speed of light, 3×10^{8} ms^{-1}.
14	2	**1.96 eV**	$E = h c / \lambda = 4.14 \times 10^{-15} \times 3 \times 10^{8} \div (632.8 \times 10^{-9}) = 1.96$ eV
15	2	On the diagram ΔE between levels must equal 1.96 or ~ 2 eV, so the transition must be between 20.7 and 18.7 eV. The arrow must point down since when an electron drops **down** to a lower energy level it emits a photon.	

Detailed study 1 – SYNCHROTRON AND ITS APPLICATIONS

Q	Marks	Answer	Reasoning
1	2	D	The electrons have an electric force that makes them accelerate along the straight sections. They have a gravitational force (their weight force) as gravity acts in the storage ring. They have a magnetic force that makes them undergo circular motion. They therefore have all three forces ∴ D.
2	2	C	Undulators are a row of magnets that produce an increase in the brightness of the synchrotron light of a particular frequency.
3	2	C	Wigglers are a row of magnets that produce an increase in the brightness of the synchrotron light of a range of frequencies.
4	2	D	Synchrotron light is across a broad spectrum → D as the only possible answer.
5	2	A	A changing electric field produces a changing magnetic field → the basis of electromagnetic radiation.
6	2	D	The charged plates will create an electric field, not a magnetic field.
7	2	D	$E = V/d = 10000 \div 0.2 = 50000\ Vm^{-1}$ or $50\ kVm^{-1}$
8	2	B	$F = Eq = 50000 \times 1.6 \times 10^{-19} = 8 \times 10^{-15}\ N$
9	2	B	$\Delta KE = qV \rightarrow \frac{1}{2} m v^2 = q V \therefore v = \sqrt{(2qV \div m)}$ $= \sqrt{(2 \times 1.6 \times 10^{-19} \times 10000 \div (9.1 \times 10^{-31}))} = 5.93 \times 10^7\ ms^{-1}$
10	2	A	$r = \frac{mv}{Bq} = 9.1 \times 10^{-31} \times 5.9 \times 10^6 \div (60 \times 10^{-3} \times 1.6 \times 10^{-19})$ $= 5.6 \times 10^{-4}$ m which converts to 0.56 mm or 560 μm
11	2	B	Bragg diffraction relies on the incident photons scattering off the layers of the atoms and then going on to interfere. Hence it must initially obey the law of reflection where the angle of incidence = the angle of reflection. Only Ray B obeys this. (Note: other rays reflected from other atom layers, although not shown in the diagram, will interfere with ray B to create the Bragg diffraction that students are told occurs.)
12	2	D	$n\lambda = 2d \sin\theta$ $1 \times \lambda = 2 \times 2 \times 10^{-10} \times \sin 5° = 3.5 \times 10^{-11}$ m 3.5×10^{-11} m $= 3.5 \times 10^{-11} \div 10^{-12}$ pm $= 35$ pm