S6 Physics Practice Paper: Electric Field and Potential, Electromagnetic Induction and Transformers, Alternating Current, Photoelectric Effect and Atomic Models, Nuclear Decay and Half-life

Level: S6 | Subject: Physics | 75 minutes | 100 marks | 24 questions | question paper

Section A Electric Field and Electric Potential (18 marks)

Show all working. Give units and answers to three significant figures.

#	Question	Marks
1	Two point charges of +4.0 x 10^-6 C and -3.0 x 10^-6 C are placed 0.30 m apart in air. (a) Find the magnitude and direction of the electrostatic force between them. (b) Find the magnitude and direction of the resultant electric field at the midpoint between them.	5
2	Two parallel metal plates 5.0 mm apart are connected to a 250 V d.c. supply. (a) Find the uniform electric field between the plates. (b) Find the force on an electron between the plates. (c) How much work must an external agent do to move a proton from the negative plate to the positive plate? Give the answer in eV and in J.	4
3	A point charge of +6.0 x 10^-6 C is isolated in air. (a) Find the potential at points 0.20 m and 0.50 m from it. (b) How much work must an external agent do to move a second charge of +2.0 x 10^-6 C from 0.50 m to 0.20 m from the first charge?	4
4	Two positive point charges of +9.0 x 10^-6 C and +4.0 x 10^-6 C are 0.50 m apart in air. (a) On the line joining them, how far from the +9.0 x 10^-6 C charge is the point where the electric field is zero? (b) Find the potential at that point.	5

Section B Electromagnetic Induction (17 marks)

State the formula used. Explain the direction of any induced current with Lenz law.

#	Question	Marks
5	A coil of area 0.015 m2 is placed in a uniform magnetic field of 0.40 T. (a) What is the magnetic flux through the coil when its plane is perpendicular to the field? (b) What is the flux when the normal to the plane makes 60 degrees with the field?	4
6	A 200-turn coil of total area 2.0 x 10^-3 m2 and resistance 4.0 ohm has its plane perpendicular to a uniform magnetic field. The field increases uniformly from 0.10 T to 0.50 T in 0.20 s. (a) Find the induced e.m.f. (b) Find the induced current. (c) Find the power dissipated in the coil. (d) Find the charge that passes any cross-section of the wire in this time.	5
7	A metal rod 0.50 m long slides at a steady 4.0 m/s on two parallel rails. Its velocity is perpendicular to a uniform field of 0.60 T, and the total circuit resistance is 3.0 ohm. (a) Find the motional e.m.f. (b) Find the induced current. (c) Find the force needed to keep the speed constant. (d) Find the mechanical power of this force and compare it with the electrical power.	4
8	A coil has a self-inductance of 0.20 H. The current through it increases uniformly from zero to 2.0 A in 0.050 s. (a) Find the induced e.m.f. across the coil. (b) Find the magnetic energy stored. (c) Explain why the self-induced e.m.f. always opposes the change in current.	4

Section C Transformers and High-voltage Transmission (17 marks)

Assume ideal transformers unless stated otherwise.

#	Question	Marks
9	An ideal transformer has 2000 turns in the primary and 100 turns in the secondary. The primary is connected to a 220 V a.c. supply and the secondary drives a load drawing 5.0 A. (a) Find the secondary voltage. (b) Find the output power. (c) Find the primary current. (d) Is this a step-up or a step-down transformer?	5
10	A transformer has an efficiency of 90%. Its input power is 500 W at 250 V and its secondary voltage is 25 V. (a) Find the output power. (b) Find the secondary current. (c) Find the primary current.	4
11	A power station delivers 50 kW at 400 V. The total resistance of the transmission cable is 0.50 ohm. (a) Find the transmission current. (b) Find the power lost in the cable. (c) Find the loss as a percentage of the power delivered.	4
12	The same station now transmits the same 50 kW through the same cable using 20 kV. (a) Find the new transmission current. (b) Find the new power loss. (c) Find the ratio of the loss at low voltage to the loss at high voltage, and explain why high-voltage transmission is more efficient.	4

Section D Alternating Current (16 marks)

All r.m.s. values and powers refer to averages over a complete cycle.

#	Question	Marks
13	The voltage of an a.c. supply varies with time as V = 340 sin(100 pi t), with V in volts and t in seconds. (a) Find the peak voltage. (b) Find the r.m.s. voltage. (c) Find the frequency. (d) Find the period.	4
14	A 100 ohm resistor is connected to an a.c. supply of r.m.s. voltage 220 V. (a) Find the r.m.s. current. (b) Find the average power dissipated. (c) Find the peak current. (d) Find the peak power.	4
15	A 20 x 10^-6 F capacitor is connected to a 50 Hz a.c. supply of r.m.s. voltage 220 V; the resistance of the circuit is negligible. (a) Find the capacitive reactance. (b) Find the r.m.s. current. (c) Explain why the reactance falls as the frequency rises.	4
16	An electric water heater is marked 2000 W, 220 V (r.m.s.). (a) Find the resistance of its heating element. (b) Find the peak current through it. (c) How many kW h of energy does it use in 3 hours of continuous operation? (d) If the supply frequency were doubled at the same voltage, would the average power change? Explain.	4

Section E Photoelectric Effect and Atomic Models (16 marks)

Take hc = 1240 eV nm, c = 3.0 x 10^8 m/s and 1 eV = 1.6 x 10^-19 J.

#	Question	Marks
17	Light of wavelength 400 nm falls on a metal surface of work function 2.3 eV. (a) Find the energy of each photon in eV. (b) Find the maximum kinetic energy of the emitted photoelectrons. (c) Find the stopping potential.	4
18	The work function of a metal is 2.3 eV. (a) Find the longest wavelength (threshold wavelength) that can cause photoemission, in nm. (b) Find the corresponding threshold frequency. (c) What happens if the incident wavelength is longer than this threshold?	4
19	Light of wavelength 500 nm falls on a metal of work function 1.9 eV. (a) Find the photon energy in eV. (b) Find the maximum kinetic energy of the photoelectrons in eV. (c) If light of 700 nm were used instead, would photoelectrons be emitted? Justify with a calculation.	4
20	The energy levels of the hydrogen atom are E1 = -13.6 eV, E2 = -3.40 eV and E3 = -1.51 eV. (a) Find the energy and wavelength (nm) of the photon emitted when the electron falls from n = 3	4

	to n = 2. (b) Find the wavelength (nm) of the photon emitted in the n = 2 to n = 1 transition. (c) To which series does each line belong?	

Section F Nuclear Decay and Half-life (16 marks)

Take 1 u = 931.5 MeV/c^2, 1 day = 86 400 s and ln 2 = 0.693.

#	Question	Marks
21	A radioisotope has a half-life of 6.0 hours. A sample has an activity of 8 000 Bq now. (a) What is the activity after 18 hours? (b) What percentage of the nuclei remain undecayed then? (c) What will the activity be after a further 6.0 hours?	4
22	The half-life of carbon-14 is 5 730 years. An archaeological sample originally contained 8.0 g of carbon-14. (a) How much carbon-14 remains after 11 460 years? (b) What percentage has decayed? (c) Why is carbon-14 dating not suitable for fossils millions of years old?	4
23	A sample contains 2.0 x 10^20 radioactive nuclei; the half-life is 5.0 days. (a) Find the decay constant in s^-1. (b) Find the present activity of the sample. (c) If the number of nuclei were doubled with the same half-life, how would the activity change?	4
24	Uranium-238 decays by alpha emission to thorium-234, which then decays by beta emission. (a) Write the two nuclear equations. (b) A nuclear reaction has a mass defect of 0.0030 u; find the energy released in MeV and in J. (c) Explain why the electron energy spectrum in beta decay is continuous.	4