

Name: _____

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A-Level Physics — Practice Exam

Instructions: A calculator is permitted. Show all working. Data: $e = 1.60 \times 10^{-19}$ C, $h = 6.63 \times 10^{-34}$ J s, $c = 3.00 \times 10^8$ m/s, $g = 9.81$ m/s², $1 \text{ u} = 931.5$ MeV.

Time Limit: 60 minutes

Multiple Choice (10 questions)

- [1 point] 1. A hadron has the quark composition uds. The charges of the quarks are $u = +\frac{2}{3}e$, $d = -\frac{1}{3}e$ and $s = -\frac{1}{3}e$. Which statement about this hadron is correct?
- A. It is a baryon with charge 0 and strangeness -1
 - B. It is a meson with charge 0
 - C. It is a baryon with charge $+e$ and strangeness $+1$
 - D. It is an antibaryon with charge 0 and strangeness -1
- [1 point] 2. Light of frequency 1.2×10^{15} Hz is incident on a metal surface whose threshold frequency is 6.0×10^{14} Hz. Take $h = 6.63 \times 10^{-34}$ J s. The maximum kinetic energy of the emitted photoelectrons is
- A. 2.0×10^{-19} J
 - B. 1.2×10^{-18} J
 - C. 8.0×10^{-19} J
 - D. 4.0×10^{-19} J
- [1 point] 3. A string of length 0.60 m is fixed at both ends. It vibrates in its second harmonic (two loops, with a node at the midpoint) at a frequency of 200 Hz. The speed of the waves on the string is
- A. 60 m/s
 - B. 120 m/s
 - C. 240 m/s
 - D. 333 m/s
- [1 point] 4. Monochromatic light of wavelength 600 nm is incident normally on a diffraction grating that has 500 lines per millimetre. The angle between the central maximum and the second-order maximum is
- A. 17.5°
 - B. 30.0°
 - C. 36.9°
 - D. 64.2°

- [1 point] 5. Light travels through glass of refractive index 1.50 towards a boundary with water of refractive index 1.33. The critical angle for this boundary is
- A. 41.8°
 - B. 48.8°
 - C. 62.5°
 - D. Total internal reflection cannot occur, because the second medium is not air
- [1 point] 6. A uniform beam of length 6.0 m and weight 300 N rests horizontally on two supports: P at the left-hand end and Q 2.0 m from the right-hand end. A load is hung from the right-hand end and gradually increased. The beam begins to tip (lose contact with P) when the load reaches
- A. 150 N
 - B. 50 N
 - C. 300 N
 - D. 450 N
- [1 point] 7. A steel wire of length 2.0 m and cross-sectional area $1.0 \times 10^{-6} \text{ m}^2$ hangs vertically and supports a load of 50 N. The Young modulus of steel is $2.0 \times 10^{11} \text{ Pa}$. The extension of the wire is
- A. 0.25 mm
 - B. 0.50 mm
 - C. 1.0 mm
 - D. 2.5 mm
- [1 point] 8. A satellite is in a circular orbit at a height equal to one Earth radius above the surface. The radius of the Earth is $6.37 \times 10^6 \text{ m}$ and the gravitational field strength at the surface is 9.81 N/kg. The orbital speed of the satellite is
- A. $4.0 \times 10^3 \text{ m/s}$
 - B. $1.1 \times 10^4 \text{ m/s}$
 - C. $7.9 \times 10^3 \text{ m/s}$
 - D. $5.6 \times 10^3 \text{ m/s}$
- [1 point] 9. A 0.50 kg mass attached to a spring of stiffness 200 N/m oscillates with simple harmonic motion of amplitude 0.040 m. The maximum acceleration of the mass is
- A. 0.80 m/s^2
 - B. 8.0 m/s^2
 - C. 16 m/s^2
 - D. 400 m/s^2
- [1 point] 10. A $470 \mu\text{F}$ capacitor is charged to 12 V and then discharged through a 10 k Ω resistor. The time taken for the potential difference across the capacitor to fall to 6.0 V is
- A. 2.4 s
 - B. 3.3 s
 - C. 4.7 s
 - D. 9.4 s

Calculations (3 questions)

[10 points] 11. A ball bearing of mass 0.020 kg is fired horizontally at 150 m/s into a wooden block of mass 0.480 kg that is at rest on a smooth horizontal bench. The ball bearing embeds itself in the block. The block then slides to the edge of the bench, which is 0.80 m above the floor, and falls to the floor. Take $g = 9.81 \text{ m/s}^2$ and ignore air resistance.

[2 points] (a) Show that the block, with the ball bearing embedded in it, leaves the collision with a speed of 6.0 m/s.

[3 points] (b) Calculate the kinetic energy lost in the collision and state what has happened to this energy.

[3 points] (c) Calculate the time the block takes to reach the floor after leaving the edge of the bench, and the horizontal distance from the edge of the bench to the point where it lands.

[2 points] (d) Explain why momentum is conserved in the collision but kinetic energy is not.

[10 points] 12. A student investigates a cell using a 1.00 m length of constantan wire as the external resistor. The wire has a diameter of 0.50 mm and the resistivity of constantan is $4.9 \times 10^{-7} \, \Omega \, \text{m}$.

[3 points] (a) Show that the resistance of the wire is approximately $2.5 \, \Omega$.

[3 points] (b) The cell has an EMF of 1.50 V. When the wire is connected across the cell, the current in the circuit is 0.50 A. Calculate the internal resistance of the cell.

[2 points] (c) Calculate the power dissipated in the wire, and the fraction of the total power generated by the cell that is dissipated in the wire.

[2 points] (d) A second, identical length of wire is now connected in parallel with the first, across the same cell. Explain, without further calculation, what happens to the terminal pd of the cell.

[10 points] 13. Cobalt-60, ${}^{60}_{27}\text{Co}$, is a beta-minus emitter used in radiotherapy. It has a half-life of 5.27 years. Data: 1 year = 3.16×10^7 s; mass of a proton = 1.00728 u; mass of a neutron = 1.00867 u; mass of a cobalt-60 nucleus = 59.9190 u; 1 u = 931.5 MeV.

[2 points] (a) Write the nuclear equation for the beta-minus decay of cobalt-60. The daughter nucleus is an isotope of nickel, Ni.

[2 points] (b) Calculate the decay constant of cobalt-60 in s^{-1} .

[3 points] (c) A new radiotherapy source contains 2.0×10^{21} cobalt-60 nuclei. Calculate the initial activity of the source and its activity after 10.0 years.

[3 points] (d) Calculate the binding energy per nucleon of the cobalt-60 nucleus, in MeV.