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Physics
Higher level
Paper 1

Tuesday 5 November 2019 (afternoon)

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[40 marks]**.

1. Which quantity has the fundamental SI units of $\text{kg m}^{-1} \text{s}^{-2}$?
 - A. Energy
 - B. Force
 - C. Momentum
 - D. Pressure
2. Two forces act along a straight line on an object that is initially at rest. One force is constant; the second force is in the opposite direction and proportional to the velocity of the object.



What is correct about the motion of the object?

- A. The acceleration increases from zero to a maximum.
 - B. The acceleration increases from zero to a maximum and then decreases.
 - C. The velocity increases from zero to a maximum.
 - D. The velocity increases from zero to a maximum and then decreases.
3. A ball falls from rest in the absence of air resistance. The position of the centre of the ball is determined at one-second intervals from the instant at which it is released. What are the distances, in metres, travelled by the centre of the ball during **each** second for the first 4.0 s of the motion?
 - A. 5, 10, 15, 20
 - B. 5, 15, 25, 35
 - C. 5, 20, 45, 80
 - D. 5, 25, 70, 150

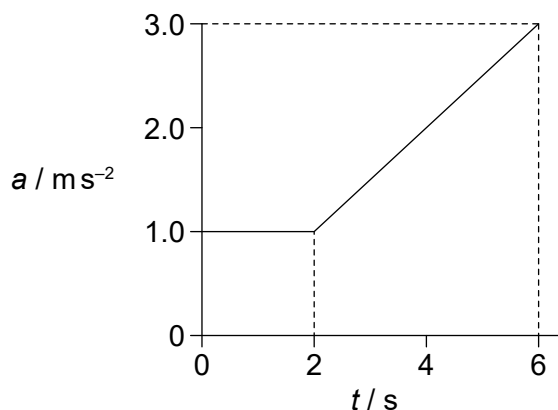
4. An object is thrown from a cliff at an angle to the horizontal. The ground below the cliff is horizontal.

Three quantities are known about this motion.

- I. The horizontal component of the initial velocity of the object
- II. The initial angle between the velocity of the object and the horizontal
- III. The height of the cliff

What are the quantities that must be known in order to determine the horizontal distance from the point of projection to the point at which the object hits the ground?

- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
5. The variation with time t of the acceleration a of an object is shown.



What is the change in velocity of the object from $t = 0$ to $t = 6$ s?

- A. 6 ms^{-1}
- B. 8 ms^{-1}
- C. 10 ms^{-1}
- D. 14 ms^{-1}

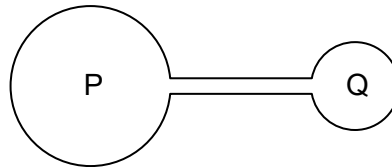
Turn over

6. A nuclear particle has an energy of 10^8 eV. A grain of sand has a mass of 32 mg. What speed must the grain of sand have for its kinetic energy to equal the energy of the nuclear particle?
- A. 1 mms^{-1}
B. 3 mms^{-1}
C. 10 mms^{-1}
D. 16 mms^{-1}
7. The tension in a horizontal spring is directly proportional to the extension of the spring. The energy stored in the spring at extension x is E . What is the work done by the spring when its extension changes from x to $\frac{x}{4}$?
- A. $\frac{E}{16}$
B. $\frac{E}{4}$
C. $\frac{3E}{4}$
D. $\frac{15E}{16}$
8. A mass m of water is at a temperature of 290 K. The specific heat capacity of water is c . Ice, at its melting point, is added to the water to reduce the water temperature to the freezing point. The specific latent heat of fusion for ice is L . What is the minimum mass of ice that is required?
- A. $\frac{17mc}{L}$
B. $\frac{290mc}{L}$
C. $\frac{17mL}{c}$
D. $\frac{290mL}{c}$

9. Under which conditions of pressure and density will a real gas approximate to an ideal gas?

	Pressure	Density
A.	high	high
B.	high	low
C.	low	high
D.	low	low

10. Two flasks P and Q contain an ideal gas and are connected with a tube of negligible volume compared to that of the flasks. The volume of P is twice the volume of Q.



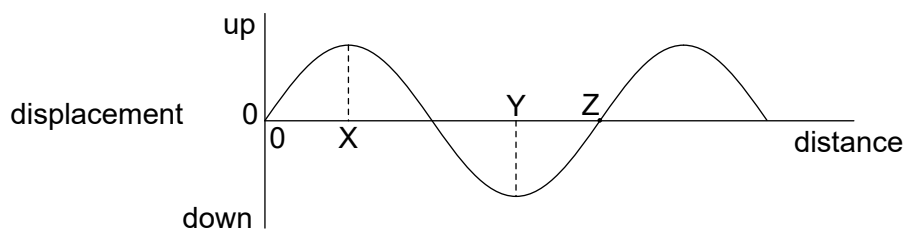
P is held at a temperature of 200K and Q is held at a temperature of 400K.

What is $\frac{\text{mass of gas in P}}{\text{mass of gas in Q}}$?

- A. $\frac{1}{8}$
- B. $\frac{1}{4}$
- C. 4
- D. 8

Turn over

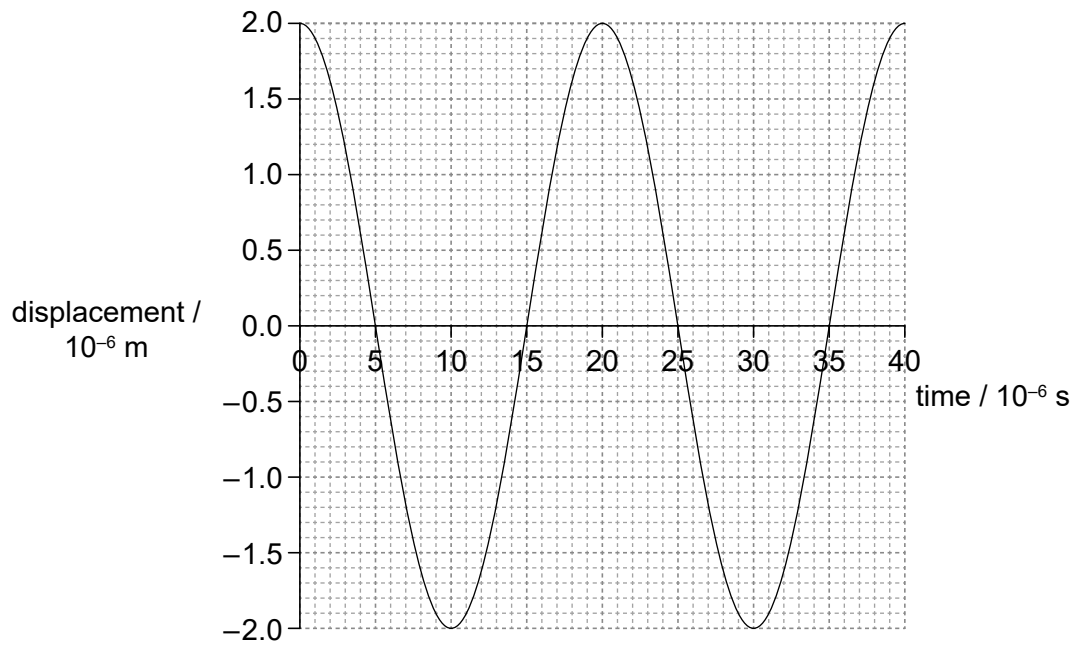
11. A transverse travelling wave is moving through a medium. The graph shows, for one instant, the variation with distance of the displacement of particles in the medium.



The frequency of the wave is 25 Hz and the speed of the wave is 100 ms^{-1} . What is correct for this wave?

- A. The particles at X and Y are in phase.
- B. The velocity of the particle at X is a maximum.
- C. The horizontal distance between X and Z is 3.0 m.
- D. The velocity of the particle at Y is 100 ms^{-1} .

12. The graph shows the variation with time for the displacement of a particle in a travelling wave.

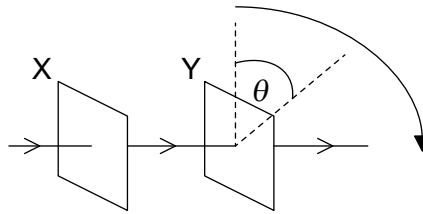


What are the frequency and amplitude for the oscillation of the particle?

	Frequency / kHz	Amplitude / μm
A.	20	2
B.	20	4
C.	50	2
D.	50	4

Turn over

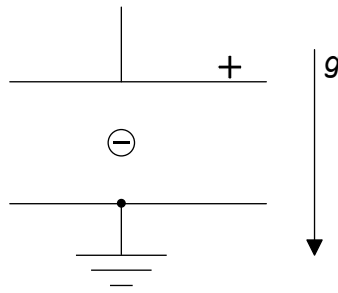
13. Unpolarized light is incident on two polarizing filters X and Y. They are arranged so that light emerging from Y has a maximum intensity. X is fixed and Y is rotated through θ about the direction of the incident beam in its own plane.



What are the first three successive values of θ for which the final transmitted intensity is a maximum?

- A. $90^\circ, 180^\circ, 270^\circ$
- B. $90^\circ, 270^\circ, 450^\circ$
- C. $180^\circ, 360^\circ, 540^\circ$
- D. $180^\circ, 540^\circ, 720^\circ$
14. A pipe of length 0.6 m is filled with a gas and closed at one end. The speed of sound in the gas is 300 m s^{-1} . What are the frequencies of the first two harmonics in the tube?
- A. 125 Hz and 250 Hz
- B. 125 Hz and 375 Hz
- C. 250 Hz and 500 Hz
- D. 250 Hz and 750 Hz

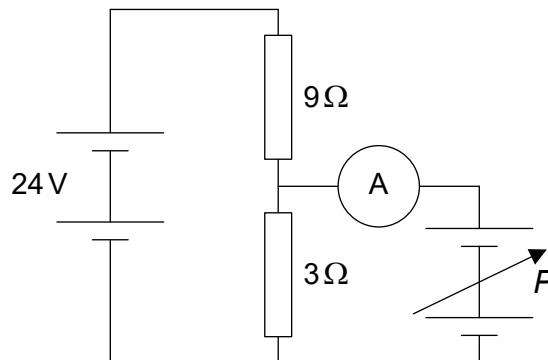
15. A negatively charged particle in a uniform gravitational field is positioned mid-way between two charged conducting plates.



The potential difference between the plates is adjusted until the particle is held at rest relative to the plates.

What change will cause the particle to accelerate downwards relative to the plates?

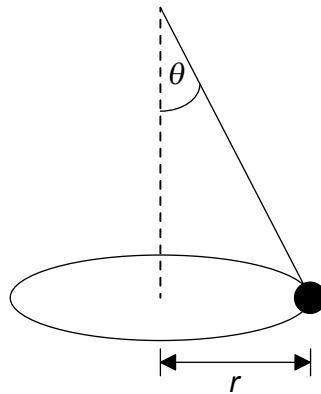
- A. Decreasing the charge on the particle
 - B. Decreasing the separation of the plates
 - C. Increasing the length of the plates
 - D. Increasing the potential difference between the plates
16. Two power supplies, one of constant emf 24 V and the other of variable emf P , are connected to two resistors as shown. Both power supplies have negligible internal resistances.



What is the magnitude of P for the reading on the ammeter to be zero?

- A. Zero
- B. 6 V
- C. 8 V
- D. 18 V

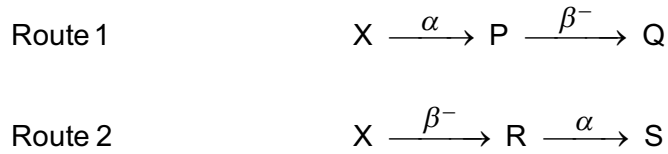
17. When a wire with an electric current I is placed in a magnetic field of strength B it experiences a magnetic force F . What is the direction of F ?
- A. In a direction determined by I only
 - B. In a direction determined by B only
 - C. In the plane containing I and B
 - D. At 90° to the plane containing I and B
18. An object hangs from a light string and moves in a horizontal circle of radius r .



The string makes an angle θ with the vertical. The angular speed of the object is ω . What is $\tan \theta$?

- A. $\frac{\omega^2 r}{g}$
- B. $\frac{g}{\omega^2 r}$
- C. $\frac{\omega r^2}{g}$
- D. $\frac{g}{\omega r^2}$

19. Nuclide X can decay by two routes. In Route 1 alpha (α) decay is followed by beta-minus (β^-) decay. In Route 2 β^- decay is followed by α decay. P and R are the intermediate products and Q and S are the final products.



Which statement is correct?

- A. Q and S are different isotopes of the same element.
 - B. The mass numbers of X and R are the same.
 - C. The atomic numbers of P and R are the same.
 - D. X and R are different isotopes of the same element.
20. A proton, an electron and an alpha particle are at rest. Which particle has the smallest magnitude of ratio of charge to mass and which particle has the largest magnitude of ratio of charge to mass?

	Smallest charge to mass ratio	Largest charge to mass ratio
A.	alpha	electron
B.	electron	alpha
C.	electron	proton
D.	proton	electron

21. Gamma (γ) radiation
- A. is deflected by a magnetic field.
 - B. affects a photographic plate.
 - C. originates in the electron cloud outside a nucleus.
 - D. is deflected by an electric field.

Turn over

22. The equations of motion for uniform acceleration
- A. apply to all accelerations.
 - B. cannot be proved mathematically.
 - C. relate force to other quantities in mechanics.
 - D. were developed through observing the natural world.

23. What are the units of specific energy and energy density?

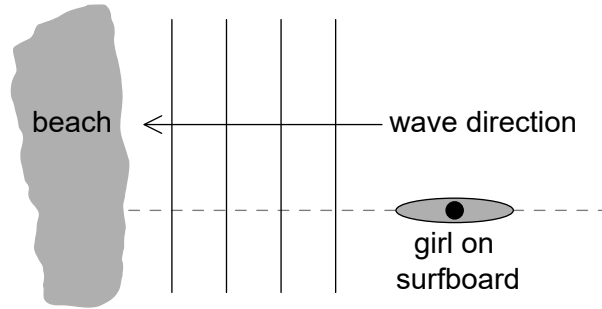
	Specific energy	Energy density
A.	J m^{-1}	J m^{-2}
B.	J kg^{-1}	J m^{-3}
C.	J kg^{-1}	J m^{-2}
D.	J m^{-1}	J m^{-3}

24. What is the function of the moderator in a thermal nuclear fission reactor?
- A. To decrease the kinetic energy of neutrons emitted from fission reactions
 - B. To increase the kinetic energy of neutrons emitted from fission reactions
 - C. To decrease the overall number of neutrons available for fission
 - D. To increase the overall number of neutrons available for fission
25. What is meant by the statement that the average albedo of the Moon is 0.1?
- A. 10% of the radiation incident on the Moon is absorbed by its surface
 - B. 10% of the radiation emitted by the Moon is absorbed by its atmosphere
 - C. 10% of the radiation incident on the Moon is reflected by its surface
 - D. 10% of the radiation emitted by the Moon is at infrared wavelengths

26. An object undergoes simple harmonic motion (shm) of amplitude x_0 . When the displacement of the object is $\frac{x_0}{3}$, the speed of the object is v . What is the speed when the displacement is x_0 ?
- A. 0
- B. $\frac{v}{3}$
- C. $\frac{\sqrt{2}}{3}v$
- D. $3v$
27. Light of frequency 500 THz is incident on a single slit and forms a diffraction pattern. The first diffraction minimum forms at an angle of 2.4×10^{-3} rad to the central maximum. The frequency of the light is now changed to 750 THz. What is the angle between the first diffraction minimum and the central maximum?
- A. 1.6×10^{-3} rad
- B. 1.8×10^{-3} rad
- C. 2.4×10^{-3} rad
- D. 3.6×10^{-3} rad
28. Light of wavelength λ is normally incident on a diffraction grating of spacing 3λ . What is the angle between the two second-order maxima?
- A. $\sin^{-1} \frac{2}{3}$
- B. $\sin^{-1} \frac{4}{3}$
- C. $2 \sin^{-1} \frac{2}{3}$
- D. $>90^\circ$ so no second orders appear

Turn over

29. Sea waves move towards a beach at a constant speed of 2.0 ms^{-1} . They arrive at the beach with a frequency of 0.10 Hz . A girl on a surfboard is moving in the sea at right angles to the wave fronts. She observes that the surfboard crosses the wave fronts with a frequency of 0.40 Hz .



What is the speed of the surfboard and what is the direction of motion of the surfboard relative to the beach?

	Speed of surfboard relative to the beach / ms^{-1}	Direction of motion of surfboard relative to the beach
A.	6.0	towards beach
B.	6.0	away from beach
C.	1.5	towards beach
D.	1.5	away from beach

30. The gravitational potential is V at a distance R above the surface of a spherical planet of radius R and uniform density. What is the gravitational potential a distance $2R$ above the surface of the planet?

- A. $\frac{V}{4}$
 B. $\frac{4V}{9}$
 C. $\frac{V}{2}$
 D. $\frac{2V}{3}$

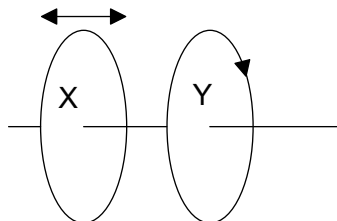
31. The force acting between two point charges is F when the separation of the charges is x . What is the force between the charges when the separation is increased to $3x$?

- A. $\frac{F}{3}$
- B. $\frac{F}{3x^2}$
- C. $\frac{F}{9}$
- D. $\frac{F}{9x^2}$

32. An electron enters a uniform electric field of strength E with a velocity v . The direction of v is not parallel to E . What is the path of the electron after entering the field?

- A. Circular
- B. Parabolic
- C. Parallel to E
- D. Parallel to v

33. X and Y are two plane coils parallel to each other that have a common axis. There is a constant direct current in Y.

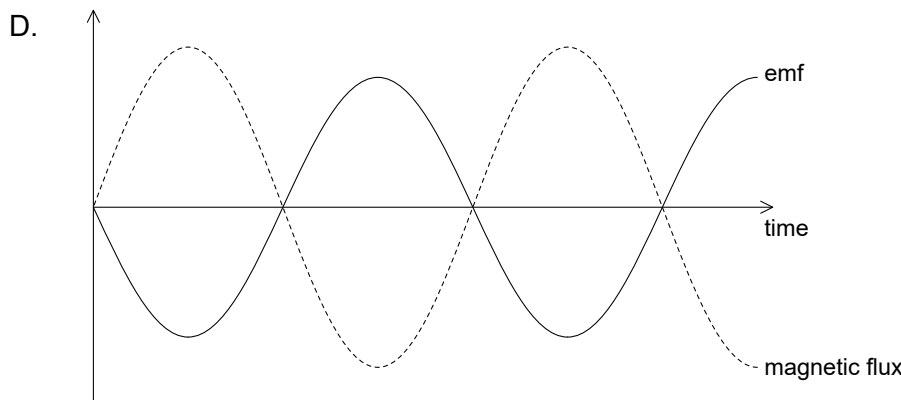
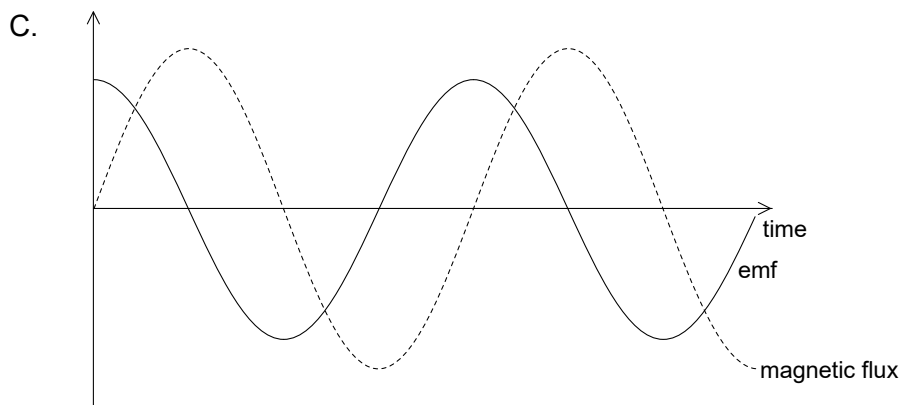
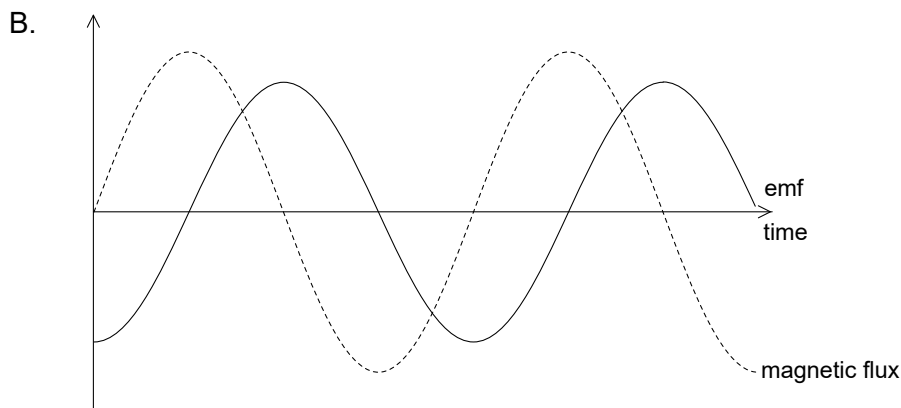
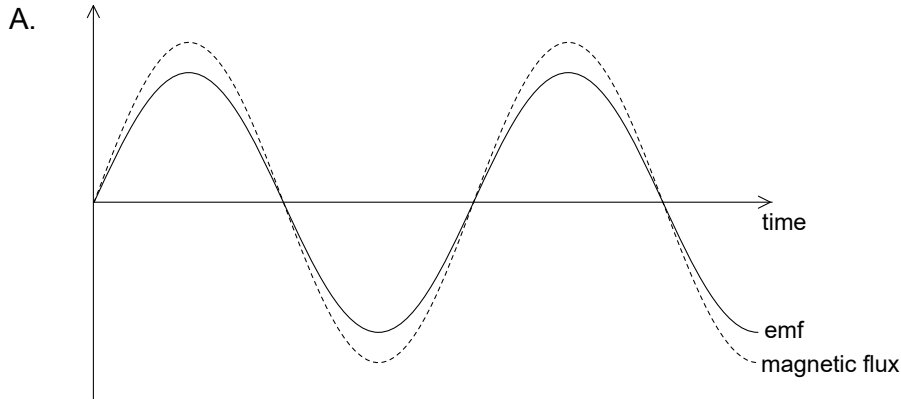


X is first moved towards Y and later is moved away from Y. What, as X moves, is the direction of the current in X relative to that in Y?

	Current direction in X as X moves towards Y	Current direction in X as X moves away from Y
A.	same direction as in Y	same direction as in Y
B.	same direction as in Y	opposite direction to Y
C.	opposite direction to Y	same direction as in Y
D.	opposite direction to Y	opposite direction to Y

Turn over

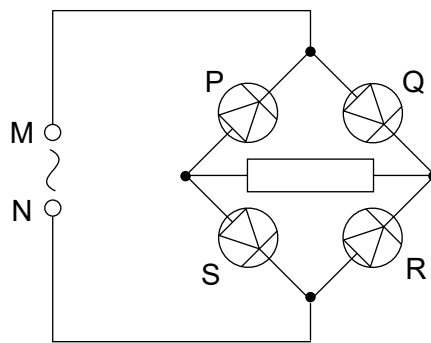
34. A coil is rotated in a uniform magnetic field. An alternating emf is induced in the coil. What is a possible phase relationship between the magnetic flux through the coil and the induced emf in the coil when the variations of both quantities are plotted with time?



35. A capacitor of capacitance $1.0\ \mu\text{F}$ stores a charge of $15\ \mu\text{C}$. The capacitor is discharged through a $25\ \Omega$ resistor. What is the maximum current in the resistor?

- A. 0.60 mA
- B. 1.7 mA
- C. 0.60 A
- D. 1.7 A

36. A diode bridge rectification circuit is constructed as shown. An alternating potential difference is applied between M and N.



Three statements about circuits are

- I. when diode P conducts, Q does not conduct
- II. when diode S conducts, neither P nor R conducts
- III. the direction of conventional current in the resistor is from left to right.

Which statements are correct for this circuit?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

Turn over

37. An electron of low energy is enclosed within a high potential barrier. What is the process by which the electron can escape?
- A. Quantum tunneling
 - B. Energy–mass conversion
 - C. Diffraction
 - D. Barrier climbing
38. A beam of monochromatic radiation is made up of photons each of momentum p . The intensity of the beam is doubled without changing frequency. What is the momentum of each photon after the change?
- A. $\frac{p}{2}$
 - B. p
 - C. $2p$
 - D. $4p$
39. Three observations of the behaviour of electrons are
- I. electron emission as a result of the photoelectric effect
 - II. electron diffraction as an electron interacts with an atom
 - III. emission of radio waves as a result of electrons oscillating in a conductor.

Which observations are evidence that the electron behaves as a particle?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

40. A pure sample of a radioactive nuclide contains N_0 atoms at time $t = 0$. At time t , there are N atoms of the nuclide remaining in the sample. The half-life of the nuclide is $t_{\frac{1}{2}}$.

What is the decay rate of this sample proportional to?

- A. N
 - B. $N_0 - N$
 - C. t
 - D. $t_{\frac{1}{2}}$
-