Q8 An unstable particle is created at one instant and decays a time ΔT_0 later in the inertial frame in which it remains stationary. How far does it travel during its lifetime in an inertial frame in which it travels at speed $c/2$? Select *one* option from the key for Q8, and pencil across *one* cell in row 8.

KEY for Q8

A $c\,\Delta T_0$

B $\dfrac{\sqrt{3}c\cdot\Delta T_0}{2}$

C $\dfrac{c\Delta T_0}{2}$

D $\dfrac{c\Delta T_0}{\sqrt{3}}$

E $\dfrac{\sqrt{3}}{4}c\Delta T_0$

(handwritten: $T' = \dfrac{t}{\sqrt{1-v^2/c^2}} = \dfrac{\partial t}{\sqrt{3}}$ $\dfrac{c\Delta T_0}{\sqrt{3}} = \infty = \dfrac{v}{t}$ $=\dfrac{c}{2}/\dfrac{2t}{\sqrt{3}} = \dfrac{ct}{\sqrt{3}}$)

Q9 Light of frequency 10^{15} Hz is incident on the surface of a metal with work function 3 eV. Which *one* of the statements in the key for Q9 correctly describes the emission of electrons from this metal due to the photoelectric effect (allowing for calculations to one significant figure)? Pencil across *one* cell in row 9.

KEY for Q9

A The minimum kinetic energy of the liberated electrons is 1 eV.

B The maximum kinetic energy of the liberated electrons is 1 eV.

C The minimum kinetic energy of the liberated electrons is 2 eV.

D The maximum kinetic energy of the liberated electrons is 2 eV.

E The light has too low a frequency to liberate any electrons.

Q10 Which of the particles listed in the key has the smallest de Broglie wavelength when accelerated from rest through a potential difference of 10^5 V? Select *one*

(handwritten:
$E = \dfrac{p^2}{2m}$ $\lambda = \dfrac{h}{p} = \dfrac{h}{\sqrt{2mE}}$
$p = \sqrt{2mE}$
$\lambda = \dfrac{h}{p}$ $E = \dfrac{p^2}{2m} \Rightarrow p = \sqrt{2mE}$
$\lambda = \dfrac{h}{\sqrt{2mE}}$ $\lambda \propto \dfrac{1}{\sqrt{m}}$*)*

option from the key for Q10, and pencil across *one* cell in row 10.

KEY for Q10

A A proton (of charge e and mass m_p)

B A singly charged ion of deuterium (of charge e and mass $2m_p$)

C A singly charged ion of helium (of charge e and mass $4m_p$)

D A singly charged ion of lithium (of charge e and mass $7m_p$)

E A singly charged ion of sodium (of charge e and mass $23m_p$)

Q11 The key for this question lists a number of statements, each giving a generally accepted explanation of an observed phenomenon. Which *one* of these statements invokes the *generalized exclusion principle* most directly? Select *one* option from the key for Q11, and pencil across *one* cell in row 11.

KEY for Q11

A Stimulated emission is the process responsible for laser radiation.

B Bose–Einstein condensation of helium-4 atoms into quantum states of low energy is related to the ability of liquid helium to flow through very fine capillaries with no apparent resistance to flow.

C The pressure exerted by electrons in a white dwarf supports it against gravitational collapse.

D The focusing of de Broglie waves associated with high-energy electrons gives the images produced by an electron microscope.

E The need for protons to tunnel through a potential barrier associated with their mutual repulsion in order to give rise to fusion accounts for the slow burning of the Sun's nuclear fuel.