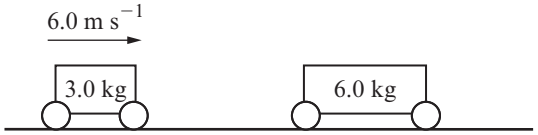
Specimen Paper 2

SL for first exams in May 2025

Q1 [4 marks]

A cart of mass 3.0 kg moving at 6.0 m s^{-1} collides with a stationary cart of mass 6.0 kg.



a Explain why the total momentum of the two carts before and after the collision is the same. **[2]**

b The two carts stick together as a result of the collision. Determine the kinetic energy lost in the collision. **[2]**

Q2 [6 marks]

a Discuss how the Rutherford-Geiger-Marsden scattering experiment led to the conclusion of the existence of an atomic nucleus. **[2]**

b A plutonium ($^{239}_{94}$Pu) nucleus decays by alpha decay into a nucleus of uranium (U).

I State the reaction equation for this decay. **[2]**

II The following binding energies per nucleon are available:

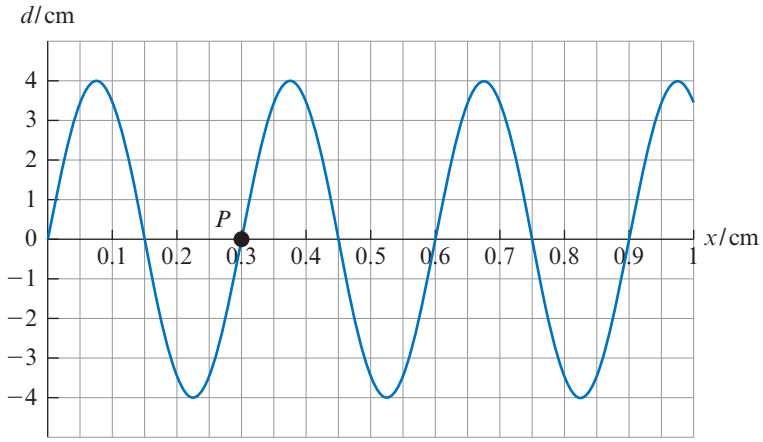
Plutonium	7.5603 MeV
Uranium	7.5909 MeV
Helium	7.0739 MeV

Estimate the energy released. **[2]**

Q3 [8 marks]

a Distinguish between a transverse and a longitudinal wave. **[2]**

b The graph shows, at $t = 0$, the variation with distance of the displacement of particles in a medium in which a transverse wave of frequency 250 Hz is travelling to the right.

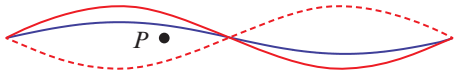


A particle P in the medium has been marked.

I Calculate the speed of the wave. **[2]**

II Draw a graph to show the variation with time t of the displacement of P. **[2]**

c A standing wave is formed on a string with both ends fixed. The solid line represents the wave at $t = 0$ and the dashed line at $t = T/2$ where T is the period. The blue line represents the wave at $t = \frac{T}{8}$.



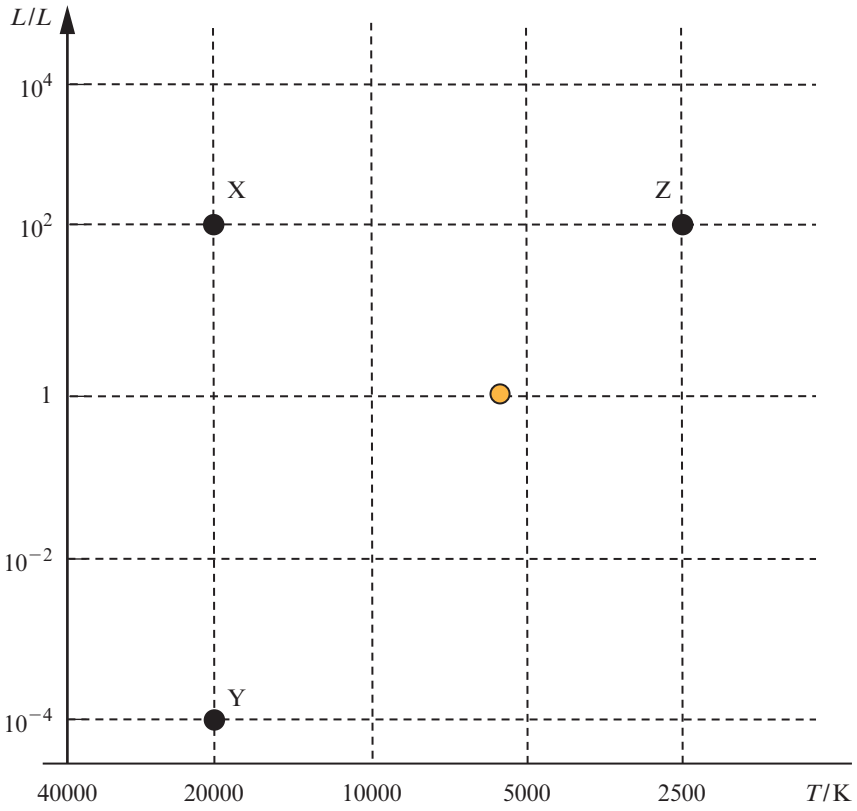
The marked point shows the **equilibrium** position of a point P on the string.
At $t = \frac{T}{8}$ draw:

I a point to indicate the position of P **[1]**

II an arrow to indicate the velocity of P. **[1]**

Q4 [7 marks]

The HR diagram shows the Sun and three other stars X, Y and Z.



a X is much hotter than Z yet X and Z have the same luminosity. Explain this observation. **[2]**

b Calculate the ratio $\frac{R_Z}{R_Y}$ of the radius of Z to that of Y. **[3]**

c Gravitational pressure tends to make stars contract. X and Y are both stable stars. State how X and Y manage to oppose their gravitational pressures.

I X **[1]**

II Y **[1]**

Q5 [5 marks]

Two parallel plates are oppositely charged. The potential difference between the plates is 240 V and their separation is 2.0 cm.

a Draw the electric field lines for this arrangement. **[2]**

b Calculate the electric field strength between the plates. **[1]**

c A proton is placed on the positively charged plate and is then released. The experiment is repeated with the proton replaced by an alpha particle.

Calculate the ratio $\frac{v_p}{v_\alpha}$ of the speed of the proton to that of the alpha particle when the particles reach the negative plate. **[2]**

Q6 [20 marks]

a A container of fixed volume holds 7.0 mol of helium ($^4_2$He) at pressure 3.0×10^5 Pa and temperature 270 K. The volume of a helium atom is about 3×10^{-30} m^3.

Calculate

I the total volume of the molecules in the container **[2]**

II the volume of the container **[2]**

III the total mass of the helium gas. **[1]**

b State and explain, by reference to the kinetic model of gases, why it is reasonable to consider helium in this container to behave as an ideal gas. **[2]**

c The gas in **a** is heated at constant volume from a pressure of 3.0×10^5 Pa and temperature 270 K to a pressure of 5.0×10^5 Pa. Calculate the new temperature of the gas. **[2]**

d Draw a line on the *P*-*V* diagram to represent the change in **c**. **[1]**

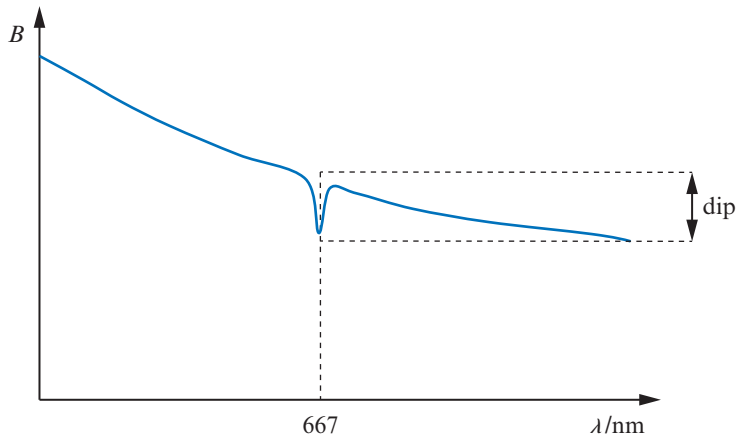
e

I Show that the change in the internal energy of helium is about 16 kJ. **[1]**

II Estimate the specific heat capacity of helium. **[2]**

f The emission spectrum of helium contains photons of energy 1.86 eV. Show that the wavelength of these photons is 667 nm. **[2]**

g The graph shows the variation of the intensity *B* of the black body radiation emitted by the Sun for wavelengths near 667 nm.



The curve shows a dip at a wavelength of 667 nm.

I Outline what is meant by black body radiation. **[2]**

II Explain why the presence of the dip is evidence that the Sun contains helium. **[3]**