**Specimen Paper 2 SL**

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.

6.0 m s-1

3.0 kg 6.0 kg

1. Explain why the total momentum of the two carts before and after the collision is the same. [2]
2. The two carts stick together as a result of the collision. Determine the kinetic energy lost in the collision. [2]

Q2 [6 marks]

1. Discuss how the Rutherford-Geiger-Marsden scattering experiment led to the conclusion of the existence of an atomic nucleus. [2]
2. A plutonium () nucleus decays by alpha decay into a nucleus of uranium (U).
3. State the reaction equation for this decay. [2]
4. 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]

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

1. Calculate the speed of the wave. [2]
2. Draw a graph to show the variation with time *t* of the displacement of P. [2]
3. 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 .



The marked point shows the **equilibrium** position of a point P on the string.

At  draw

1. a point to indicate the position of P. [1]
2. 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.

1

40000 20000 10000 5000 2500 *T*/K

102

104

10-2



10-4

X

Y

Z

1. X is much hotter than Z yet X and Z have the same luminosity. Explain this observation. [2]
2. Calculate the ratio  of the radius of Z to that of Y. [3]
3. Gravitational pressure tends to make stars contract. X and Y are both stable stars. State how X and of Y manage to oppose their gravitational pressures.
4. X [1]
5. 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.

+ \_

1. Draw the electric field lines for this arrangement. [2]
2. Calculate the electric field strength between the plates. [1]
3. 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 of the speed of the proton to that of the alpha particle when the particles reach the negative plate. [2]

Q6 [20 marks]

1. A container of fixed volume holds 7.0 mol of helium () at pressure 3.0×105 Pa and temperature 270 K. The volume of a helium atom is about 3×10-30 m3.

Calculate

1. the total volume of the molecules in the container, [2]
2. the volume of the container, [2]
3. the total mass of the helium gas. [1]
4. 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]
5. The gas in (a) is heated at constant volume from a pressure of 3.0×105 Pa and temperature 270 K to a pressure of 5.0×105 Pa. Calculate the new temperature of the gas. [2]
6. Draw a line on the *P*-*V* diagram to represent the change in (c). [1]

*P*

0

0

1. Show that the change in the internal energy of helium is about 16 kJ. [1]
2. Estimate the specific heat capacity of helium. [2]
3. The emission spectrum of helium contains photons of energy 1.86 eV. Show that the wavelength of these photons is 667 nm. [2]
4. The graph shows the variation of the intensity *B* of the black body radiation emitted by the Sun for wavelengths near 667 nm.

667 *λ*/nm

*B*

dip

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

1. Outline what is meant by black body radiation. [2]
2. Explain why the presence of the dip is evidence that the Sun contains helium. [3]

**Markscheme**

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| --- | --- | --- | --- | --- |
| **1** |  |  |  |  |
| a |  | The total momentum stays the same when no external forces act on the system✓  The carts exert equal and opposite forces on each other so the net force is zero✓ |  | [2] |
| b |  | ✓  Change in KE: ✓ |  | [2] |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **2** |  |  |  |  |
| a |  | A very small percentage of the incident alpha particles were scattered at very large scattering angles✓  This required a huge electric force that could only be provided if the positive charge of the atom was concentrated in a very small, massive object✓ |  | [2] |
| b | i | Correct numbers for U✓ |  | [2] |
| b | ii | ✓  5.25 MeV✓ |  | [2] |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **3** |  |  |  |  |
| a |  | In a transverse wave the displacement is at right angles to the direction of energy transfer✓  In a longitudinal wave the displacement is parallel to the direction of energy transfer ✓ |  | [2] |
| b | i | ✓  ✓ |  | [2] |
| b | ii | Correct shape✓  Correct period✓ |  | [2] |
| c | i | ✓ |  | [1] |
| c | ii | ✓ |  | [1] |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **4** |  |  |  |  |
| a |  | Luminosity also depends on area✓  Star Z has a much larger area than X✓ |  | [2] |
| b | i | ✓  ✓  ✓ |  | [3] |
| c | i | X: by radiation pressure caused by fusion reactions✓ |  | [1] |
| c | ii | Y: by electron degeneracy pressure✓ |  | [1] |

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| --- | --- | --- | --- | --- |
| **5** |  |  |  |  |
| a |  | Uniform lines from left to right in the interior✓  Edge effects✓ |  | [2] |
| b |  | ✓ |  | [1] |
| c |  | ✓  ✓ |  | [2] |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **6** |  |  |  |  |
| a | i | ✓  ✓ |  | [2] |
| a | ii | ✓  ✓ |  | [2] |
| a | iii | ✓ |  | [1] |
| b |  | One of the assumptions of the kinetic theory of gases states that the volume of the molecules is negligible compared to the volume of the gas ✓  Here  which is very small ✓ |  | [2] |
| c |  | ✓  ✓ |  | [2] |
| d |  | *VV*  *P*  0  0  Vertical straight line ✓ |  | [1] |
| e | i | ✓ |  | [1] |
| e | ii | Realization that ✓  ✓ |  | [2] |
| f |  | ✓  ✓ |  | [2] |
| g | i | [2] max from  Electromagnetic radiation with an infinite rage of wavelengths✓  With a peak determined by temperature ✓  Radiation emitted by a body at some finite kelvin temperature ✓  Radiation with an intensity proportional to the 4th power of the kelvin temperature✓ |  | [2]  max |
| g | ii | Helium has energy levels separated by 1.86 eV✓  This energy difference is unique to helium✓  The dip implies that photons of this energy are absorbed ✓  By helium |  | [3] |