1. (a) State what is represented by gravitational field lines.

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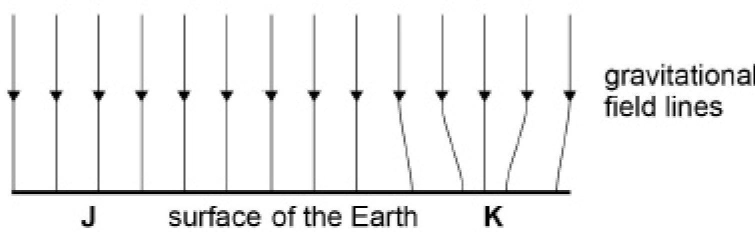
(1)

(b) **Figure 1** shows the gravitational field above a small horizontal region on the surface of the Earth.

Figure 1



Suggest why the field lines converge over a small area at **K**.

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(2)

(c) A ball travelling at constant speed passes position **J** moving towards position **K** in **Figure 1**.

Assume friction is negligible.

Explain any change in the speed of the ball as it approaches **K**.

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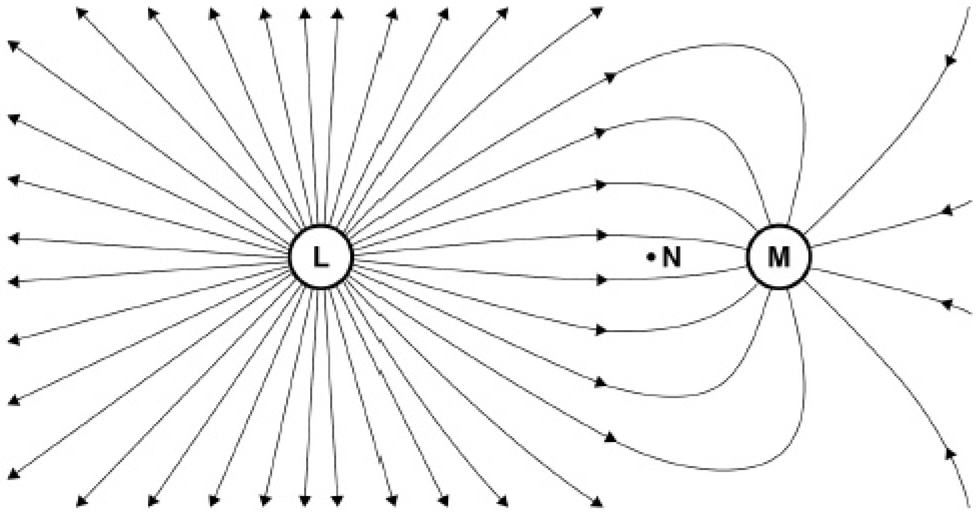
(2)

(d) **Figure 2** shows lines of force for the electric field surrounding two charged objects **L** and **M**.

Figure 2



Explain why the lines of force shown in **Figure 2** cannot represent a gravitational field.

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(1)

(e) State which object **L** or **M** has a charge with the greater magnitude.

object ____________________

State which object **L** or **M** has a positive charge.

object ____________________

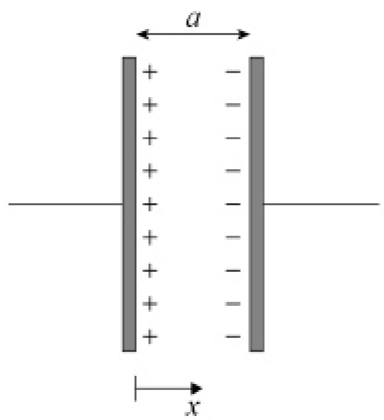
(1)

(f) Draw, on **Figure 2**, an equipotential line that passes through point **N**.
Do **not** extend your line beyond the given field lines.

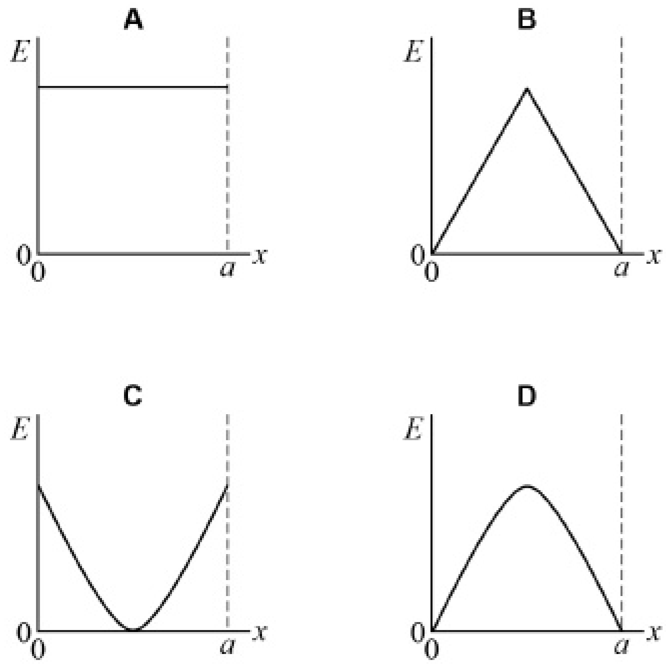
(2)

(Total 9 marks)

2. Two parallel metal plates of separation a carry equal and opposite charges.



Which graph best represents how the electric field strength E varies with the distance x in the space between the two plates?



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

3. A particle of mass m and charge q is accelerated through a potential difference V over a distance d.

What is the average acceleration of the particle?

A $\frac{qV}{md}$ ☐

B $\frac{mV}{qd}$ ☐

C $\frac{V}{mqd}$ ☐

D $\frac{dV}{mq}$ ☐

(Total 1 mark)

4. An electron on the surface of the Earth is placed in an electric field of strength 5000 N C^{-1}.

What is $\left(\frac{\text{electric force}}{\text{gravitational force}}\right)$ for the electron?

A 1.1×10^{-14} ☐

B 2.9×10^{-10} ☐

C 3.4×10^{9} ☐

D 9.0×10^{13} ☐

(Total 1 mark)

5. An α particle makes a head−on collision with a gold nucleus containing 79 protons. The distance of closest approach of the α particle to the nucleus is 4.0×10^{-14} m.

What electrostatic force acts on the gold nucleus when at this separation?

A 9.1×10^{-11} N ☐

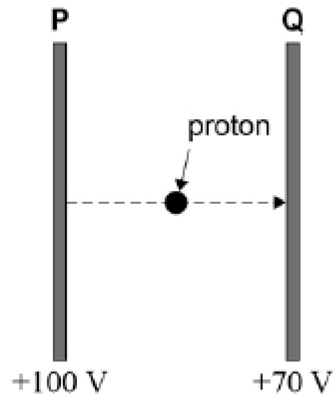
B 23 N ☐

C 290 N ☐

D 1.4×10^{20} N ☐

(Total 1 mark)

6. Two fixed parallel metal plates **P** and **Q** are at constant electrical potentials of +100 V and +70 V respectively. A proton travelling from **P** to **Q** experiences a force F due to the electric field between **P** and **Q**, and a change of potential energy of ΔE_p.



Which line, **A** to **B**, in the table gives the direction of F and the value of ΔE_p?

	Direction of F	ΔE_p	
A	towards **P**	+30 eV	⬭
B	towards **Q**	+30 eV	⬭
C	towards **Q**	−30 eV	⬭
D	towards **P**	−30 eV	⬭

(Total 1 mark)

7. An electron moves through a distance of 0.10 m parallel to the field lines of a uniform electric field of strength 2.0 kN C^{-1}.

What is the work done on the electron?

A zero ⬭

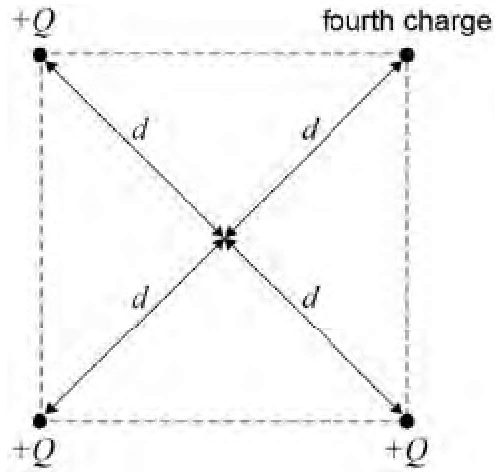
B 1.6×10^{-17} J ⬭

C 3.2×10^{-17} J ⬭

D 1.6×10^{-21} J ⬭

(Total 1 mark)

8. Four positive charges are fixed at the corners of a square as shown.



The total potential at the centre of the square, a distance d from each charge, is $\frac{5Q}{4\pi\varepsilon_o d}$

Three of the charges have a charge of +Q

What is the magnitude of the fourth charge?

A $-\frac{7Q}{4}$ ○

B Q ○

C $\sqrt{2}Q$ ○

D $2Q$ ○

(Total 1 mark)

9. A charged spherical conductor has a radius r. An electric field of strength E exists at the surface due to the charge.

What is the potential of the spherical conductor?

A $r^2 E$ ○

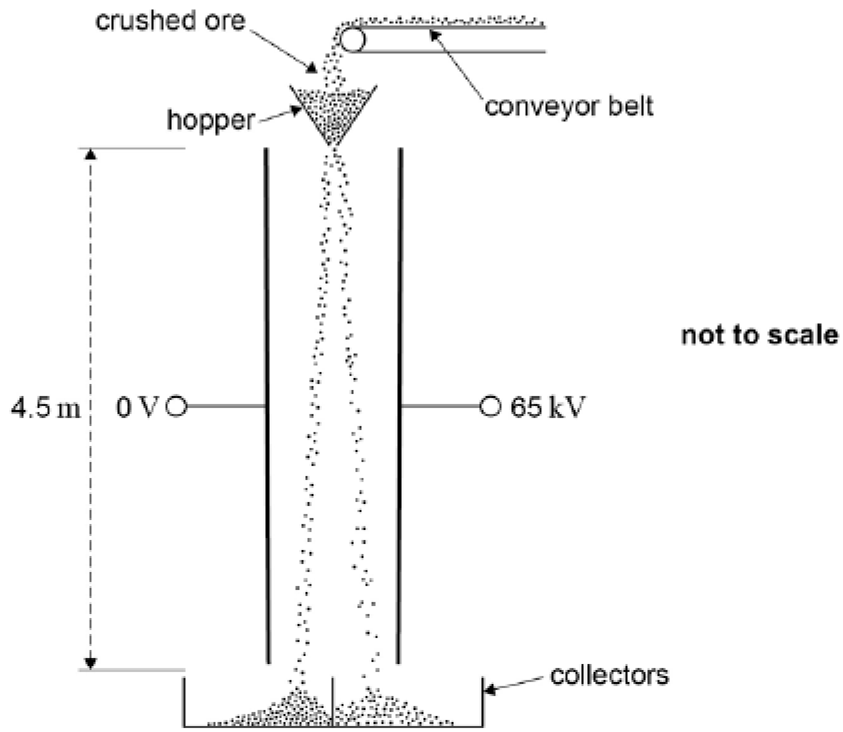
B $r E^2$ ○

C $\frac{E}{r}$ ○

D $r E$ ○

(Total 1 mark)

10. The figure below shows a system that separates two minerals from the ore containing them using an electric field.



The crushed particles of the two different minerals gain opposite charges due to friction as they travel along the conveyor belt and through the hopper. When they leave the hopper they fall 4.5 metres between two parallel plates that are separated by 0.35 m.

(a) Assume that a particle has zero velocity when it leaves the hopper and enters the region between the plates.

Calculate the time taken for this particle to fall between the plates.

time taken = ____________ s

(2)

(b) A potential difference (pd) of 65 kV is applied between the plates.

Show that when a particle of specific charge 1.2×10^{-6} C kg^{-1} is between the plates its horizontal acceleration is about 0.2 m s^{-2}.

(3)

(c) Calculate the total horizontal deflection of the particle that occurs when falling between the plates.

horizontal deflection = ______________m

(1)

(d) Explain why the time to fall vertically between the plates is independent of the mass of a particle.

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(2)

(e) State and explain **two** reasons, why the horizontal acceleration of a particle is different for each particle.

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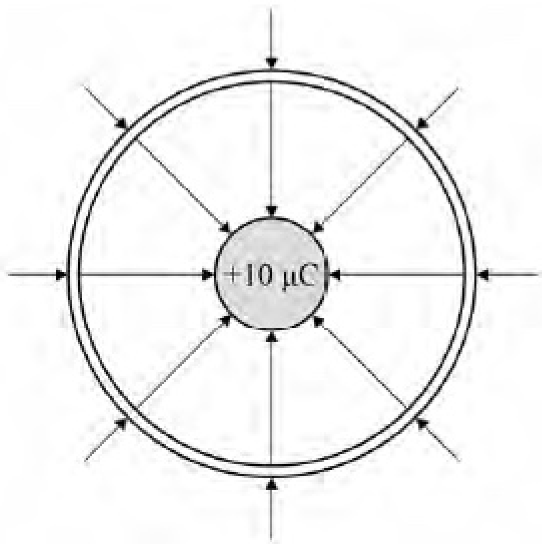
(4)

(Total 12 marks)

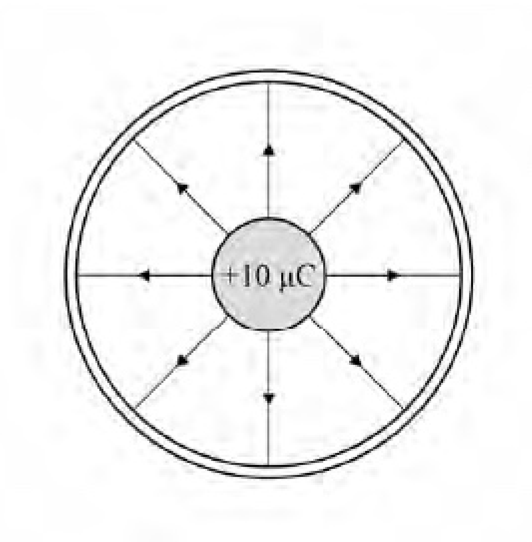
11. A conducting sphere holding a charge of +10 μC is placed centrally inside a second uncharged conducting sphere.

Which diagram shows the electric field lines for the system?

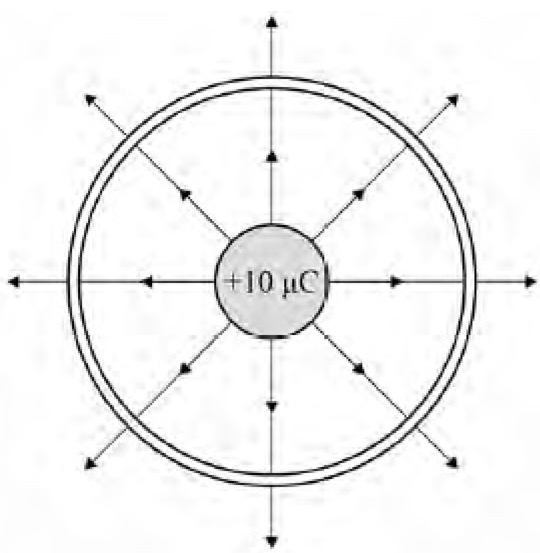
A



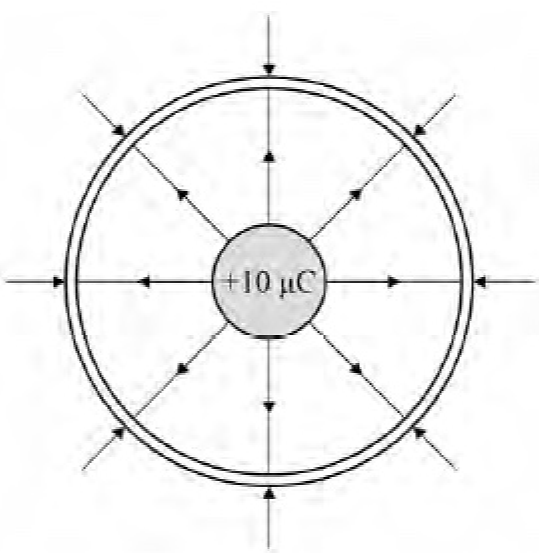
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

12. The ionisation potential for the atoms of a gas is V. Electrons of mass m and charge e travelling at a speed v can just cause ionisation of atoms in the gas.

What is V?

A $\frac{eV}{2m}$ ⬭

B $\frac{2eV}{m}$ ⬭

C $\sqrt{\frac{eV}{2m}}$ ⬭

D $\sqrt{\frac{2eV}{m}}$ ⬭

(Total 1 mark)

13. An electric field acts into the plane of the paper. An electron enters the field at 90° to the field lines.

The force on the electron is

A zero. ⬭

B along the direction of the field. ⬭

C at 90° to the field. ⬭

D opposite to the direction of the field. ⬭

(Total 1 mark)

14. A positive charge of 2.0×10^{-4} C is placed in an electric field at a point where the potential is +500 V.

What is the potential energy of the system?

A 1.0×10^{-1} J

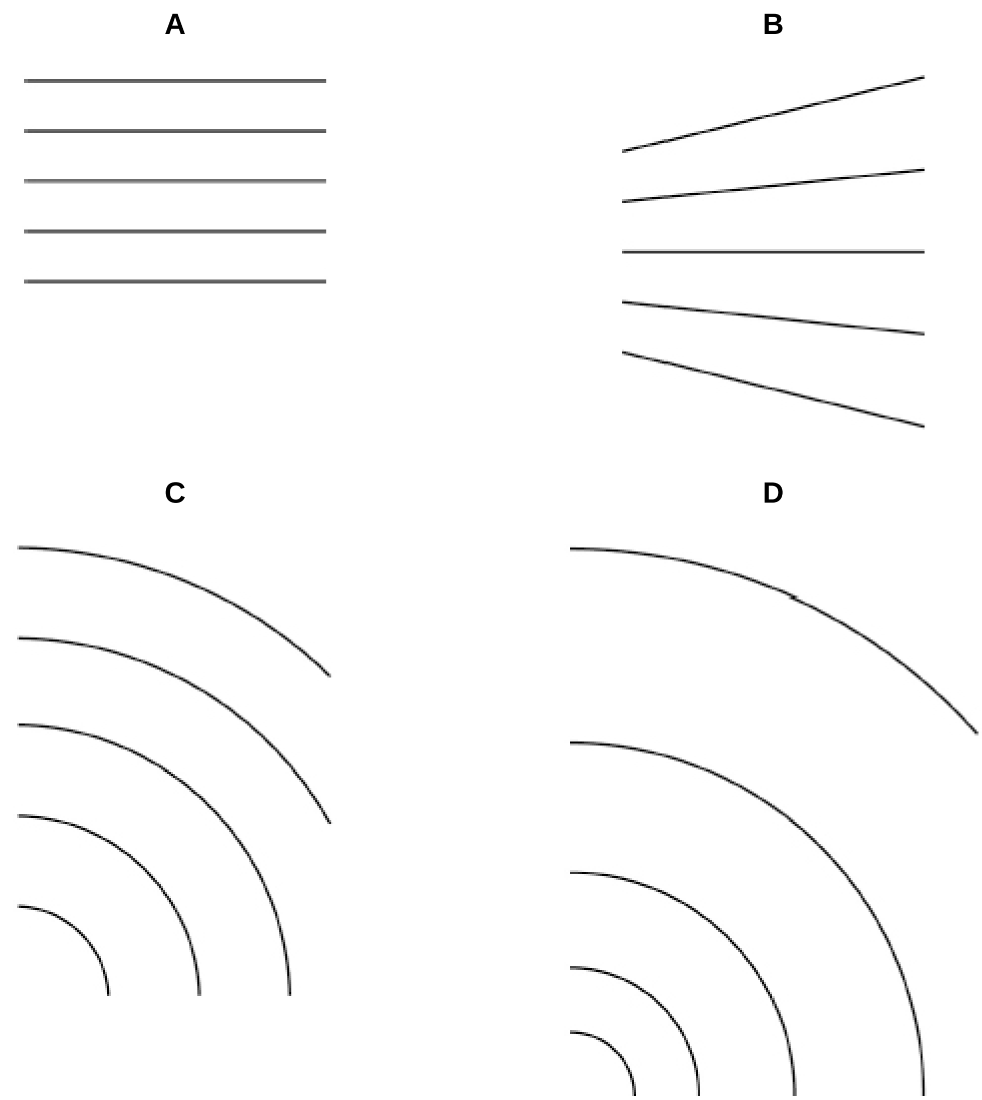
B 1.0×10^{-1} J C^{-1}

C 4.0×10^{-7} J

D 4.0×10^{-7} J C^{-1}

(Total 1 mark)

15. Which diagram shows lines of equipotential in steps of equal potential difference near an isolated point charge?



A ☐

B ☐

C ☐

D ☐

(Total 1 mark)

16. Two fixed charges of magnitude $+Q$ and $+3Q$ repel each other with a force F. An additional charge of $-2Q$ is given to each charge.

What are the magnitude and the direction of the force between the charges?

	Magnitude of force	Direction of force	
A	$\frac{F}{3}$	repulsive	⬭
B	$5F$	attractive	⬭
C	$5F$	repulsive	⬭
D	$\frac{F}{3}$	attractive	⬭

(Total 1 mark)

17. At a distance L from a fixed point charge, the electric field strength is E and the electric potential is V.

What are the electric field strength and the electric potential at a distance $3L$ from the charge?

	Electric field strength	Electric potential	
A	$\frac{E}{3}$	$\frac{V}{9}$	⬭
B	$\frac{E}{3}$	$\frac{V}{3}$	⬭
C	$\frac{E}{9}$	$\frac{V}{3}$	⬭
D	$\frac{E}{9}$	$\frac{V}{9}$	⬭

(Total 1 mark)

18. (a) Explain, in terms of binding energy, why energy can be released when two nuclei undergo nuclear fusion.

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(2)

(b) During the collapse of a supermassive star, helium-3 and oxygen-17 fuse to release energy. The equation for this reaction is

$$^{3}_{2}\mathrm{He} + {}^{17}_{8}\mathrm{O} \rightarrow {}^{20}_{10}\mathrm{Ne}$$

The table below gives data for these nuclei.

Nucleus	**Mass / u**
$^{3}_{2}\mathrm{He}$	3.01603
$^{17}_{8}\mathrm{O}$	16.99913
$^{20}_{10}\mathrm{Ne}$	19.99244

Calculate, in J, the energy released when this reaction occurs.

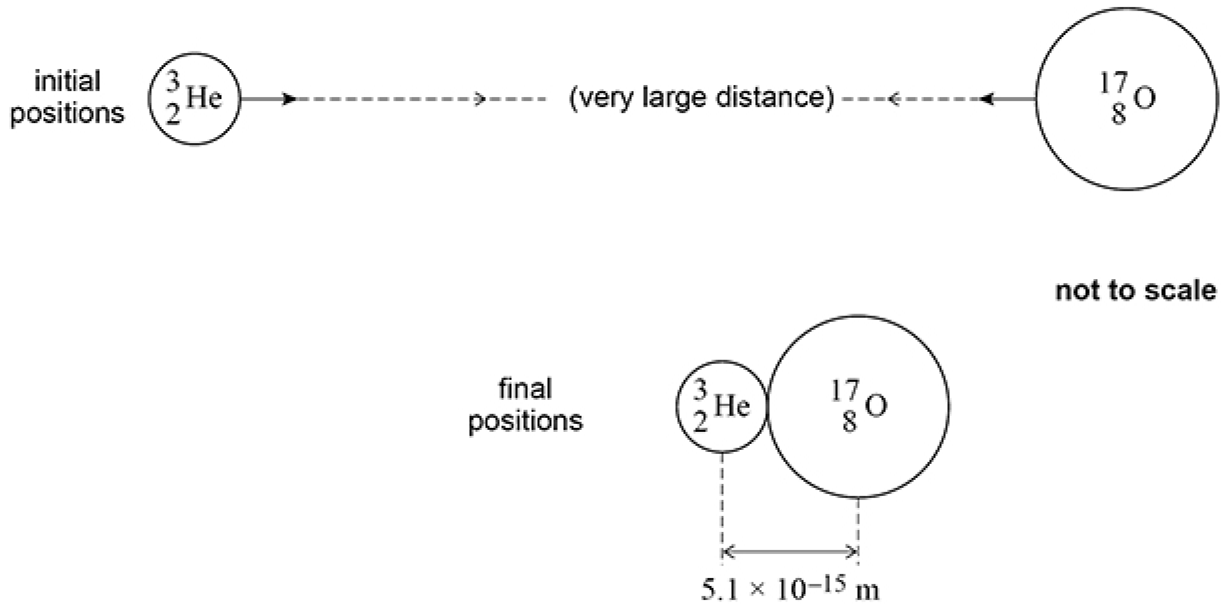
energy released = ____________________ J

(2)

(c) One model of nuclear fusion suggests that fusion happens when nuclei touch.

Initially the helium nucleus and oxygen nucleus are separated so that the force between them is negligible. They move towards each other until they fuse. Fusion occurs when their centres are separated by a distance of 5.1×10^{-15} m.

The figure below shows the initial positions and final positions of the nuclei.



Calculate the total change in electrostatic potential energy between the initial positions and final positions of the nuclei.

change in electrostatic potential energy = _______________ J

(2)

(d) $^{3}_{2}He$ can undergo fusion reactions with either $^{34}_{16}S$ or $^{17}_{8}O$ at the same temperature in a star.

The nucleus has properties that depend on its proton number and its nucleon number. These properties affect the fusion reaction.

Discuss, for this star, how these properties affect the rate of fusion of $^{34}_{16}S$ with $^{3}_{2}He$ compared to the rate of fusion of $^{17}_{8}O$ with $^{3}_{2}He$.

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(3)

(Total 9 marks)