Q1. In the equation $X = \frac{ab}{r^n}$, X represents a physical variable in an electric or a gravitational field, a is a constant, b is either mass or charge and n is a number.

Which line, **A** to **D**, in the table provides a consistent representation of X, a and b according to the value of n?

The symbols E, g, V and r have their usual meanings.

	n	***X***	***a***	***b***
A	1	E	$\frac{1}{4\pi\varepsilon_0}$	charge
B	1	V	$\frac{1}{4\pi\varepsilon_0}$	mass
C	2	g	G	mass
D	2	V	G	charge

(Total 1 mark)

Q2.(a) State, in words, Coulomb's law.

.....

.....

.....

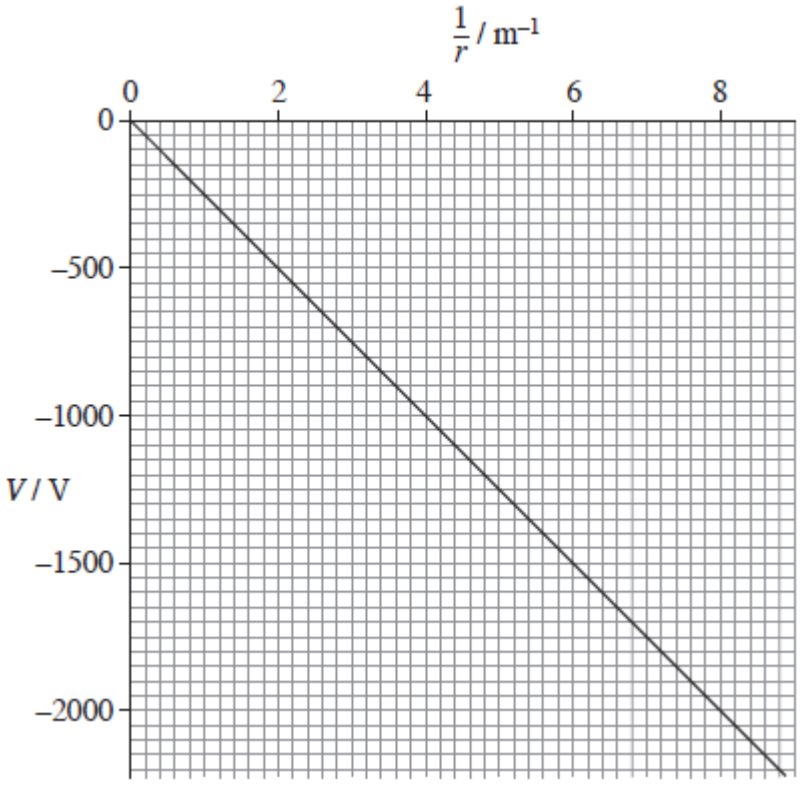
.....

.....

.....

(2)

(b) The graph shows how the electric potential, V, varies with $\frac{1}{r}$, where r is the distance from a point charge Q.



State what can be deduced from the graph about how V depends on r and explain why all the values of V on the graph are negative.

.....

.....

.....

.....

(2)

(c) (i) Use data from the graph to show that the magnitude of Q is about 30 nC.

(2)

(ii) A +60 nC charge is moved from a point where r = 0.20 m to a point where r = 0.50 m. Calculate the work done.

(2)

work done ..... J

(iii) Calculate the electric field strength at the point where r = 0.40 m.

electric field strength ..... V m^{-1}

(2)
(Total 10 marks)

Q3. In stars, helium-3 and helium-4 are formed by the fusion of hydrogen nuclei. As the temperature rises, a helium-3 nucleus and a helium-4 nucleus can fuse to produce beryllium-7 with the release of energy in the form of gamma radiation.

The table below shows the masses of these nuclei.

Nucleus	**Mass / u**
Helium-3	3.01493
Helium-4	4.00151
Beryllium-7	7.01473

(a) (i) Calculate the energy released, in J, when a helium-3 nucleus fuses with a helium-4 nucleus.

energy released ..... J

(4)

(ii) Assume that in each interaction the energy is released as a single gamma-ray photon.

Calculate the wavelength of the gamma radiation.

wavelength ..... m

(3)

(b) For a helium-3 nucleus and a helium-4 nucleus to fuse they need to be separated by no more than 3.5×10^{-15} m.

(i) Calculate the minimum total kinetic energy of the nuclei required for them to reach a separation of 3.5×10^{-15} m.

total kinetic energy ..... J

(3)

(ii) Calculate the temperature at which two nuclei with the average kinetic energy

for that temperature would be able to fuse.
Assume that the two nuclei have equal kinetic energy.

temperature ..... K

(3)

(c) Scientists continue to try to produce a viable fusion reactor to generate energy on Earth using reactors like the Joint European Torus (JET). The method requires a plasma that has to be raised to a suitable temperature for fusion to take place.

(i) State **two** nuclei that are most likely to be used to form the plasma of a fusion reactor.

1 .....

2 .....

(2)

(ii) State **one** method which can be used to raise the temperature of the plasma to a suitable temperature.

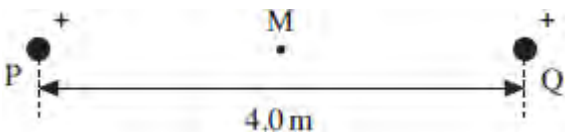
.....

.....

(1)

(Total 16 marks)

Q4. Two identical positive point charges, P and Q, are separated by a distance of 4.0 m.
The resultant electric potential at point M, which is mid-way between the charges, is 25.0 V.



What would be the resultant electrical potential at a point 1.0 m closer to P?

A 8.3 V

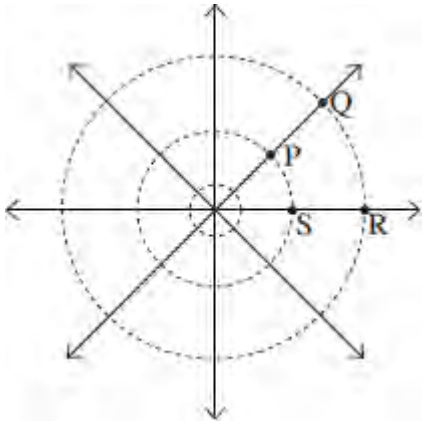
B 12.5 V

C 33.3 V

D 37.5 V

(Total 1 mark)

Q5. The diagram below shows the field lines and equipotential lines around an isolated positive point charge.



Which one of the following statements concerning the work done when a small charge is moved in the field is **incorrect**?

A when it is moved from either P to Q or S to R, the work done is the same in each case

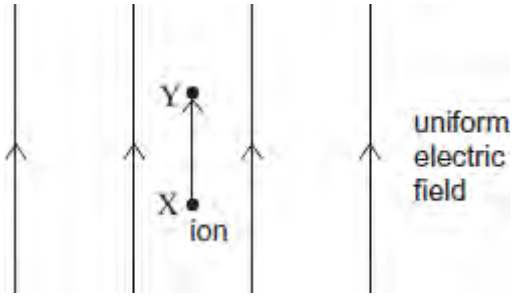
B when it is moved from Q to R no work is done

C when it is moved around the path PQRS, the overall work done is zero

D when it is moved around the path PQRS, the overall work done is equal to twice the work done in moving from P to Q

(Total 1 mark)

Q6. A uniform electric field of electric field strength E is aligned so it is vertical. An ion moves vertically through a small distance Δd from point X to point Y in the field.
There is a uniform gravitational field of field strength g throughout the region.



Which line, **A** to **D**, in the table correctly gives the gravitational potential difference, and the electric potential difference, between X and Y?

	Gravitational potential difference	**Electric potential difference**
A	$g\Delta d$	$E\Delta d$
B	$g\Delta d$	$\frac{E}{\Delta d}$
C	$\frac{g}{\Delta d}$	$E\Delta d$
D	$\frac{g}{\Delta d}$	$\frac{E}{\Delta d}$

(Total 1 mark)

Q7. Two horizontal parallel plate conductors are separated by a distance of 5.0 mm in air. The lower plate is earthed and the potential of the upper plate is +50 V.

Which line, **A** to **D**, in the table gives correctly the electric field strength, *E*, and the potential, *V*, at a point midway between the plates?

	electric field strength *E* / Vm^{-1}	**potential *V* / V**
A	1.0×10^4 upwards	25
B	1.0×10^4 downwards	25
C	1.0×10^4 upwards	50
D	1.0×10^4 downwards	50

(Total 1 mark)

Q8. Two identical positive point charges, P and Q, separated by a distance *r*, repel each other with a force *F*. If *r* is decreased so that the electrical potential energy of Q is doubled, what is the force of repulsion?

A 0.5 *F*

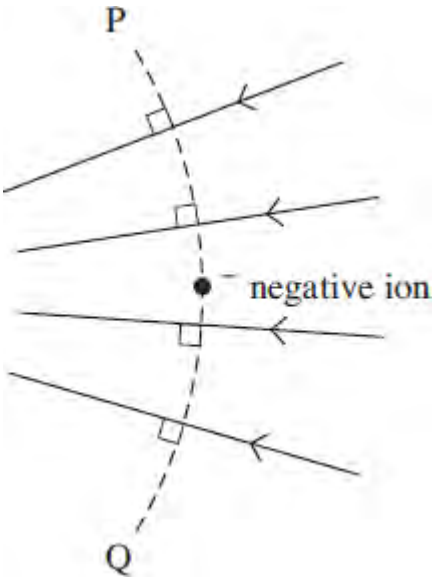
B *F*

C 2*F*

D 4*F*

(Total 1 mark)

Q9. The diagram shows a negative ion at a point in an electric field, which is represented by the arrowed field lines.



Which one of the following statements correctly describes what happens when the ion is displaced?

When the negative ion is displaced

A to the left the magnitude of the electric force on it decreases.

B to the right its potential energy increases.

C along the line PQ towards Q its potential energy decreases.

D along the line PQ towards P the magnitude of the electric force on it is unchanged.

(Total 1 mark)

Q10. When a charge moves between two points in an electric field, or a mass moves between two points in a gravitational field, energy may be transferred.
Which one of the following statements is correct?

A No energy is transferred when the movement is parallel to the direction of the field.

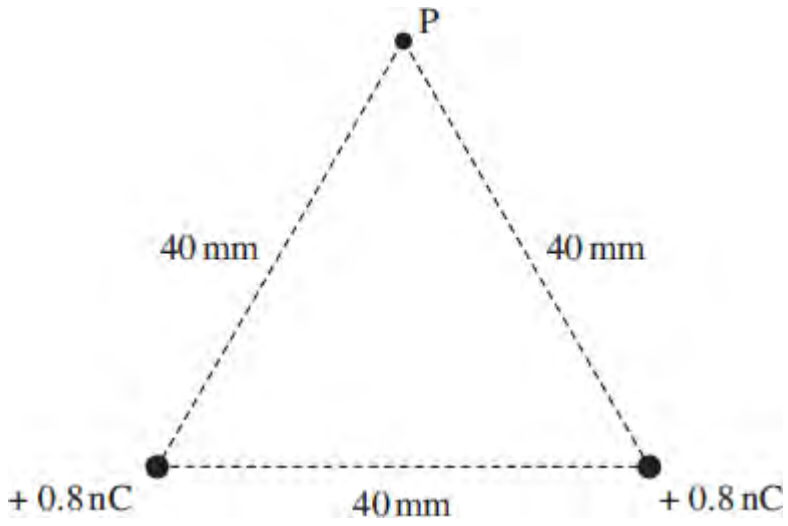
B The energy transferred is independent of the path followed.

C The energy transferred is independent of the start and finish points.

D Energy is transferred when the movement is perpendicular to the field lines.

(Total 1 mark)

Q11. Two charges, each of + 0.8 nC, are 40 mm apart. Point P is 40 mm from each of the charges.



What is the electric potential at P?

A zero

B 180 V

C 360 V

D 4500 V

(Total 1 mark)

Q12. (a) Define the electric potential at a point in an electric field.

.....

.....

.....

.....

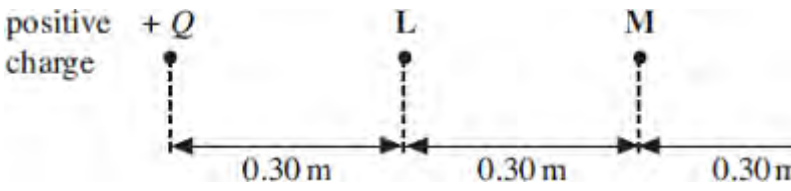
.....

.....

(3)

(b) **Figure 1** shows part of the region around a small positive charge.

Figure 1



(b) (i) The electric potential at point **L** due to this charge is + 3.0 V. Calculate the magnitude *Q* of the charge. Express your answer to an appropriate number of significant figures.

answer = ... C

(3)

(ii) Show that the electric potential at point **N**, due to the charge, is +1.0 V.

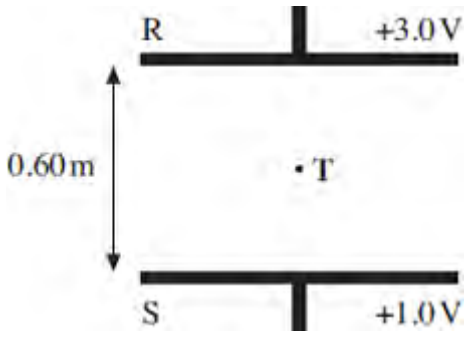
(1)

(iii) Show that the electric field strength at point **M**, which is mid-way between **L** and **N**, is 2.5 Vm^{-1}.

(1)

(c) R and S are two charged parallel plates, 0.60 m apart, as shown in **Figure 2**. They are at potentials of + 3.0 V and + 1.0 V respectively.

Figure 2



(i) On **Figure 2**, sketch the electric field between R and S, showing its direction.

(2)

(ii) Point **T** is mid-way between R and S.
Calculate the electric field strength at **T**.

answer = ... Vm^{-1}

(1)

(iii) Parts (b)(iii) and (c)(ii) both involve the electric field strength at a point mid-way between potentials of + 1.0 V and + 3.0 V. Explain why the magnitudes of these electric field strengths are different.

.....

.....

.....

(1)

(Total 12 marks)