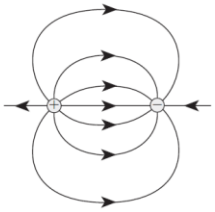
Electrostatics Review

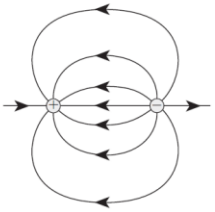
Multiple Choice

1. Which of the following diagrams shows the electric field between two equal but opposite charges?

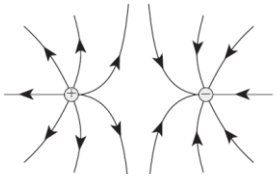
A.



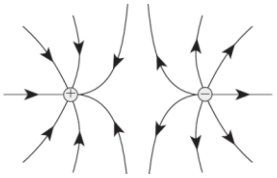
B.



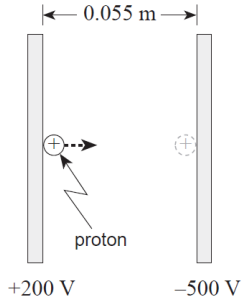
C.



D.



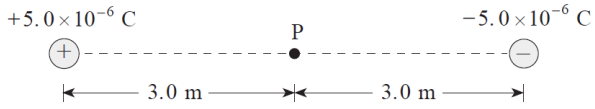
2. A proton initially at rest is accelerated between parallel plates through a potential difference of 700 V.



What is the maximum speed reached by the proton?

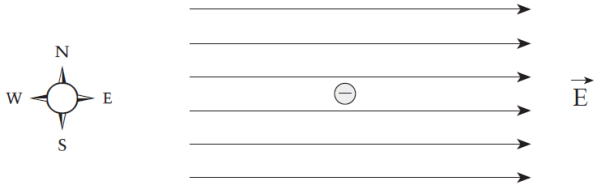
A. 8.6×10^{4} m/s
B. 3.1×10^{5} m/s
C. 3.7×10^{5} m/s
D. 1.6×10^{6} m/s

3. What are the magnitudes of the electric field and the electric potential at point P midway between the two fixed charges?



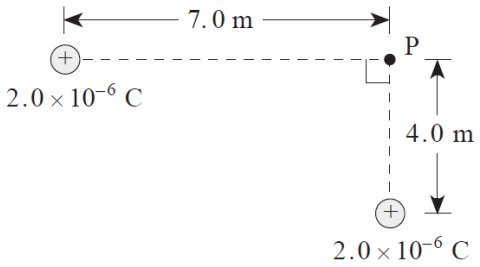
	Magnitude of Electric Field	Electric Potential
A.	0 N/C	0 V
B.	0 N/C	30 000 V
C.	10 000 N/C	0 V
D.	10 000 N/C	30 000 V

4. An electron in the electric field has an electric force acting on it in what direction?



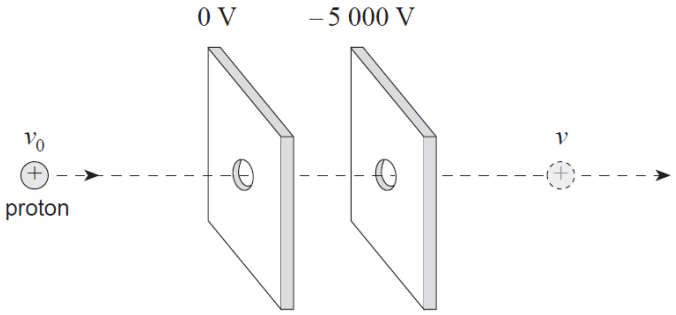
A. North
B. South
C. East
D. West

5. What is the electric potential at point P due to the two fixed charges as shown?



A. 1 200 V
B. 1 500 V
C. 5 200 V
D. 7 100 V

6. A moving proton has 6.4×10^{-16} J of kinetic energy. The proton is accelerated by a potential difference of 5 000 V between parallel plates.



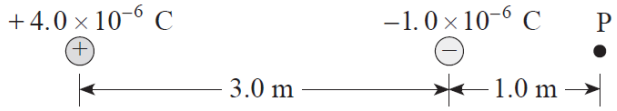
The proton emerges from the parallel plates with what speed?

A. 8.8×10^5 m/s
B. 9.8×10^5 m/s
C. 1.3×10^6 m/s
D. 1.8×10^6 m/s

7. The electric field is uniform between

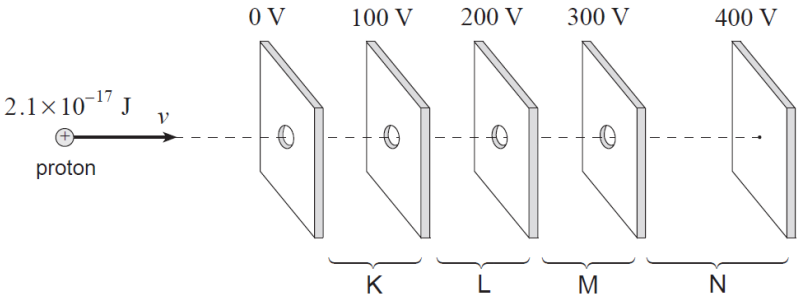
A. two positive point charges.
B. two negative point charges.
C. two opposite point charges.
D. two oppositely charged parallel plates.

8. What is the magnitude and direction of the electric field at point P due to the two fixed charges?



	ELECTRIC FIELD AT POINT P	
	MAGNITUDE	DIRECTION
A.	6 800 N/C	Right
B.	6 800 N/C	Left
C.	11 000 N/C	Right
D.	11 000 N/C	Left

9. A proton with kinetic energy of 2.1×10^{-17} J is moving into a region of charged parallel plates. The proton will be stopped momentarily in what region?

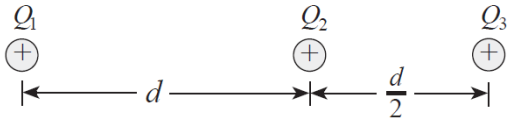


A. Region K
B. Region L
C. Region M
D. Region N

10. Which of the following best describes how electric potential varies with distance in the region around a point charge?

A. $V \propto r$
B. $V \propto \frac{1}{r}$
C. $V \propto r^2$
D. $V \propto \frac{1}{r^2}$

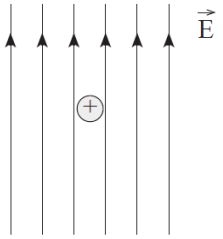
11. Three **identical** positive electric charges are fixed as shown in the diagram below.



What is the direction of the net electric force on Q_2 due to Q_1 and Q_3?

A. to the left
B. to the right
C. the net force is zero
D. cannot be determined

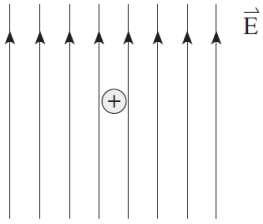
12. In an experiment, a positively charged oil droplet weighing 0.9×10^{-14} N is held stationary by a vertical electric field as shown in the diagram.



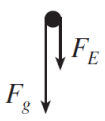
If the electric field strength is 5.3×10^{3} N/C, what is the charge on the oil droplet?

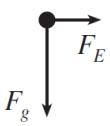
A. 1.2×10^{-18} C
B. 3.4×10^{-11} C
C. 4.1×10^{4} C
D. 8.2×10^{17} C

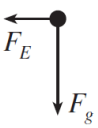
13. A positively charged oil droplet is in a vertical electric field.



Which of the following is a correctly labelled free-body diagram showing the forces acting on the oil droplet?

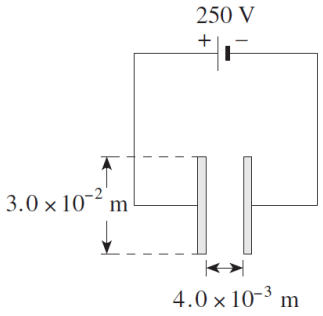
A. 

B. 

C. 

D. 

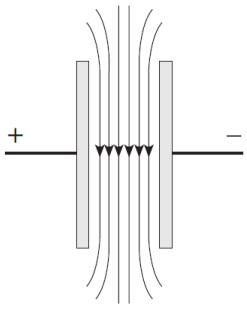
14. What are the magnitude and direction of the electric field between the plates in the situation shown below?



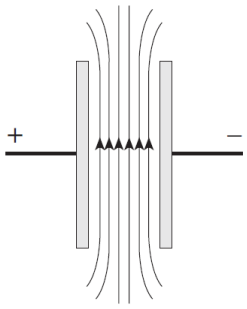
	DIRECTION OF FIELD	MAGNITUDE OF FIELD (V/m)
A.	left	8.3×10^{3}
B.	right	8.3×10^{3}
C.	left	6.3×10^{4}
D.	right	6.3×10^{4}

15. Which of the following best illustrates the electric field between parallel plates with opposite electric charges?

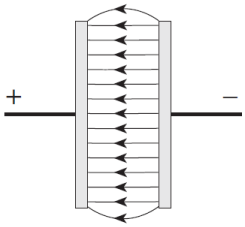
A.



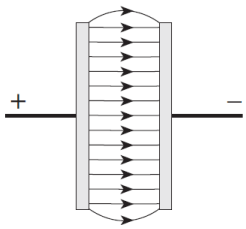
B.



C.



D.



16. The atomic nucleus of uranium contains 92 protons. What is the direction and magnitude of the electric field 2.5×10^{-10} m from this nucleus?

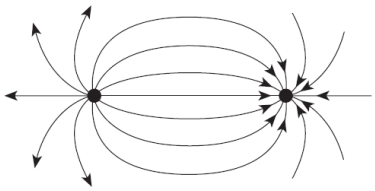
	DIRECTION OF ELECTRIC FIELD	MAGNITUDE OF ELECTRIC FIELD
A.	towards nucleus	5.3×10^{2} N/C
B.	away from nucleus	5.3×10^{2} N/C
C.	towards nucleus	2.1×10^{12} N/C
D.	away from nucleus	2.1×10^{12} N/C

17. A 0.16 C charge is moved in an electric field from a point with a potential of 25 V to another point with a potential of 95 V. How much work was done to move this charge?

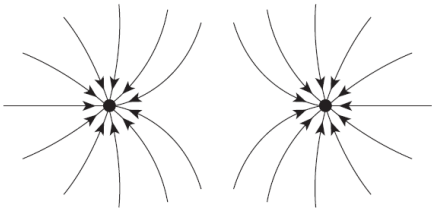
A. 4.0 J
B. 11 J
C. 15 J
D. 19 J

18. Which of the following shows the electric field for two opposite unequal point charges?

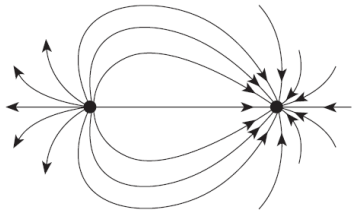
A.



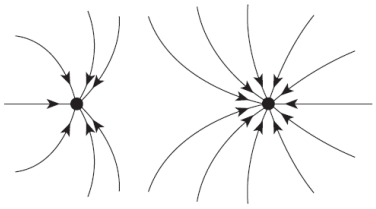
B.



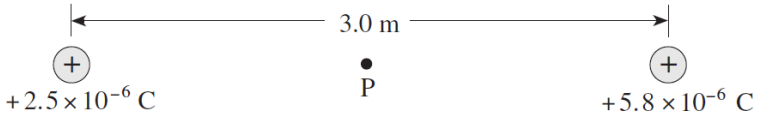
C.



D.



19. Two positive point charges are placed 3.0 m apart as shown.



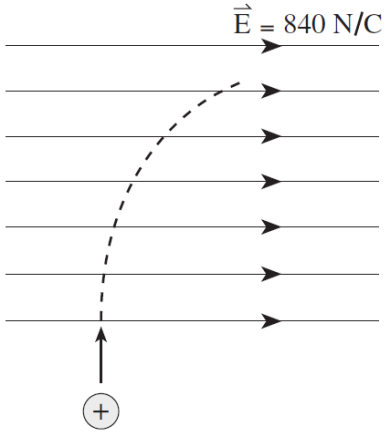
What is the magnitude of the electric field at point P midway between the two charges?

A. 0 N/C
B. 3 300 N/C
C. 13 000 N/C
D. 33 000 N/C

20. Which of the following are correct units for electric potential?

A. J/s
B. J/C
C. N/m
D. N/C

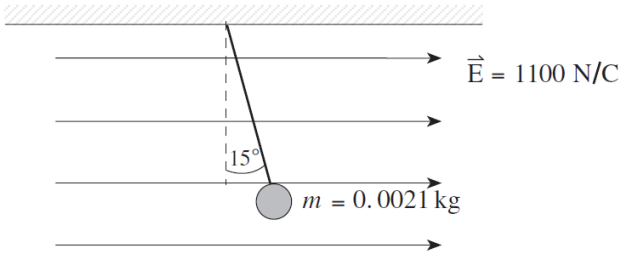
21. A proton beam is fired into a uniform electric field. The protons follow a parabolic path as shown.



What is the acceleration of these protons?

A. 1.3×10^{-16} m/s^2
B. 8.0×10^{10} m/s^2
C. 1.5×10^{14} m/s^2
D. 5.0×10^{29} m/s^2

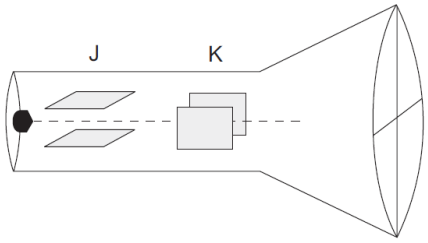
22. A small 0.0021 kg plastic ball is suspended by a string in a uniform electric field as shown.



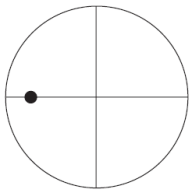
If the string makes an angle of 15° with the vertical, as indicated, what is the charge on the ball?

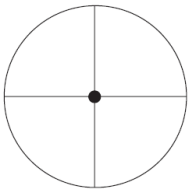
A. 4.8×10^{-6} C
B. 5.0×10^{-6} C
C. 1.9×10^{-5} C
D. 5.5×10^{-3} C

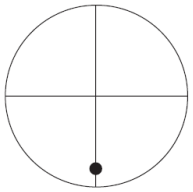
23. In the CRT shown below, a potential difference is only applied to the set of plates at J.

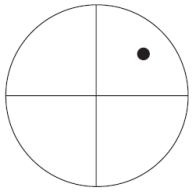


Which of the following could show the position of the electron beam on the screen?

A.


B.


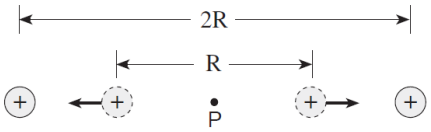
C.


D.


24. In one model of the hydrogen atom, the electron orbits the proton at a distance of 5.1×10^{-11} m. What is the electrostatic force between these two particles?

A. 3.9×10^{-47} N
B. 5.3×10^{-27} N
C. 4.5×10^{-18} N
D. 8.9×10^{-8} N

25. Two equal positive point charges are placed at distance R from each other. They are then moved to a distance of 2R away from each other. The electric potential and electric field at point P midway between the charges are measured before and after the move.

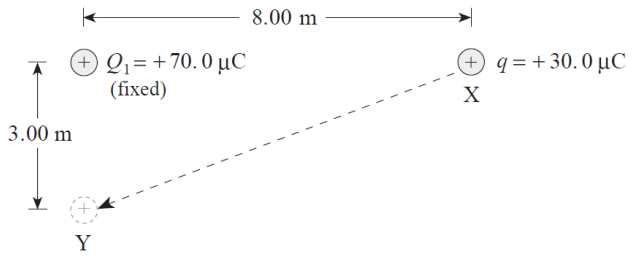


Which of the following is correct?

	NEW ELECTRIC POTENTIAL	NEW ELECTRIC FIELD
A.	half the original electric potential	half the original electric field
B.	same as the original electric potential	half the original electric field
C.	half the original electric potential	same as the original electric field
D.	same as the original electric potential	same as the original electric field

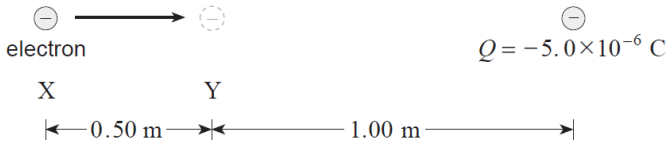
Written Response

1. A charge q of $30.0\ \mu C$ is moved from point X to point Y.



How much work is done on the $30.0\ \mu C$ charge? $(1\ \mu C = 1\times10^{-6}\ C)$ **(7 marks)**

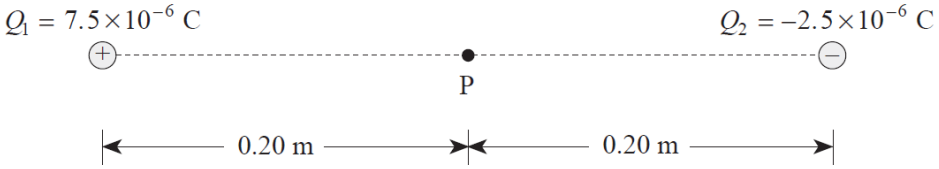
2. a) How much work is done in moving an electron from point X to point Y? **(5 marks)**



b) What is the potential difference between point X and point Y? **(2 marks)**

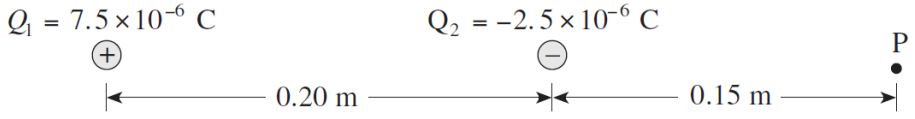
3. A proton, initially at rest at point X, will have what speed at point Y? **(7 marks)**

4. Electric charges are arranged as shown in the diagram below.



What is the electric field (magnitude and direction) at point P midway between the charges? **(7 marks)**

5. Electric charges Q_1 and Q_2 are arranged as shown in the diagram below.

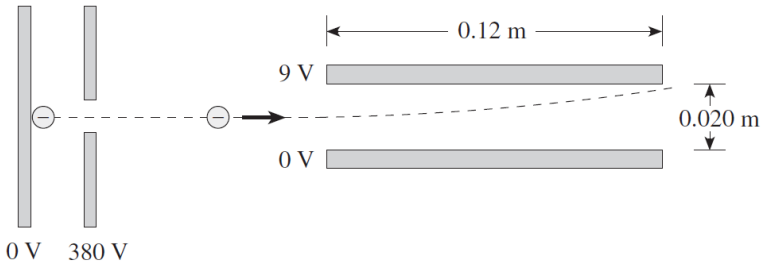


What is the electric potential at point P? **(7 marks)**

6. A student decides to investigate how electric field varies along the line connecting two positive point charges. Charge Q_2 is greater than charge Q_1.

Using principles of physics, describe the electric field along the line from Q_1 to Q_2. **(4 marks)**

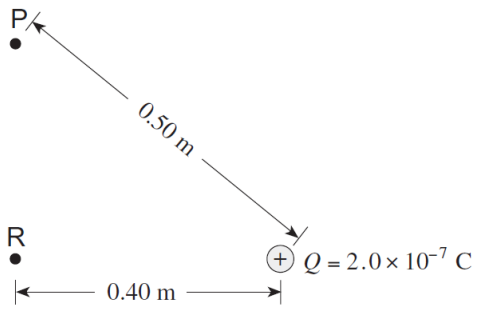
7. A beam of electrons is directed to a region between oppositely charged parallel plates as shown in the diagram below.



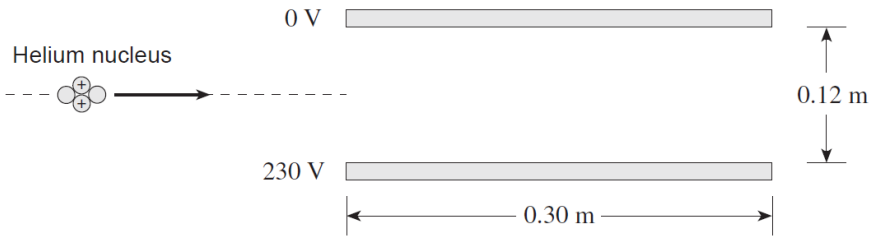
a) The electron beam is produced by accelerating electrons through an electric potential difference of 380 V. What is the speed of the electrons as they leave the 380 V plate? **(3 marks)**

b) What is the electrostatic force on electrons in the region between the horizontal plates when they are connected to a 9.0 V potential difference? **(4 marks)**

8. What is the electric potential difference between points P and R due to the fixed point charge Q? **(7 marks)**



9. A helium nucleus having twice the charge and four times the mass of a proton is travelling with high velocity when it enters a set of charged plates as shown.



a) Find the magnitude of the acceleration of the helium nucleus due to these plates. **(5 marks)**

A proton travelling at the same velocity as the helium nucleus is then sent through these same plates. Explain, using principles of physics, why the acceleration of the proton is larger than that of the helium nucleus. **(4 marks)**

Answers

MC

1. A
2. C
3. C
4. D
5. D
6. C
7. D
8. B
9. B
10. B
11. A
12. A
13. D
14. D
15. D
16. D
17. B
18. C
19. C
20. B
21. B
22. B
23. C
24. D
25. C

WR

1. How much work is done on the $30.0\ \mu C$ charge? $\left(1\ \mu C = 1\times10^{-6}\ \text{C}\right)$ **(7 marks)**

$W = \Delta E$ ← **1 mark**

$= E_{p_y} - E_{p_x}$ ← **2 marks**

$= \frac{kQq}{r_y} - \frac{kQq}{r_x}$ ← **1 mark**

$= \frac{9.00\times10^{9}\cdot70.0\times10^{-6}\cdot30.0\times10^{-6}}{3.00} - \frac{9.00\times10^{9}\cdot70.0\times10^{-6}\cdot30.0\times10^{-6}}{8.00}$ ← **2 marks**

$= (6.3-2.4)\ \text{J}$

$= 3.9\ \text{J}$ ← **1 mark**

2.

$$W = \Delta Ep$$
$$= \frac{kQq}{r_2} - \frac{kQq}{r_1}$$ ← **2 marks**

$$= \frac{9.0\times10^{9}\times-5.0\times10^{-6}\times-1.60\times10^{-19}}{1.00} - \frac{9.0\times10^{9}\times-5.0\times10^{-6}\times-1.60\times10^{-19}}{1.50}$$ ← **2 marks**

$$= 2.4\times10^{-15}\ \text{J}$$ ← **1 mark**

b) What is the potential difference between point X and point Y? **(2 marks)**

$$\Delta V = \frac{W}{q} = 1.5\times10^{4}\ \text{V}$$ ← **2 marks**

Note: Both positive and negative answers will be accepted for b)

3.

$$\Delta E = 0$$
$$\Delta E_k = -\Delta Ep$$ ← **1 mark**

$$E_{k_2} - E_{k_1} = E_{p_1} - E_{p_2}$$

$$\tfrac{1}{2}mv_2^{\,2} - 0 = \frac{kQq}{r_1} - \frac{kQq}{r_2}$$ ← **3 marks**

$$= \frac{9.0\times10^{9}\cdot3.5\times10^{-6}\cdot1.6\times10^{-19}}{1.0} - \frac{9.0\times10^{9}\cdot3.5\times10^{-6}\cdot1.6\times10^{-19}}{3.0}$$ ← **2 marks**

$$= \frac{5.04\times10^{-15}}{1} - \frac{5.04\times10^{-15}}{3}$$

$$= 5.04\times10^{-15} - 1.68\times10^{-15}$$

$$\tfrac{1}{2}mv^2 = 3.36\times10^{-15}$$

$$\tfrac{1}{2}\left(1.67\times10^{-27}\right)v^2 = 3.36\times10^{-15}$$

$$v = 2.0\times10^{6}\ \text{m/s}$$ ← **1 mark**

4.

$$E_1 = \frac{kQ_1}{r_1^{\,2}}$$
$$= \frac{9.0\times10^{9}\cdot7.5\times10^{-6}}{(0.20)^2}$$
$$= 1.69\times10^{6}\ \text{N/C}\ (\text{right})$$ ← **1 ½ marks**

$$E_2 = \frac{kQ_2}{r_2^{\,2}}$$
$$= \frac{9.0\times10^{9}\cdot2.5\times10^{-6}}{(0.20)^2}$$
$$= 5.63\times10^{5}\ \text{N/C}\ (\text{right})$$ ← **1 ½ marks**

$$E_T = E_1 + E_2$$ ← **2 marks**

$$= 1.69\times10^{6}\ \text{N/C} + 5.63\times10^{5}\ \text{N/C}$$

$$= 2.25\times10^{6}\ \text{N/C}\ (\text{right})$$

$$= 2.3\times10^{6}\ \text{N/C}\ (\text{right})$$ ← **2 marks**

5.

What is the electric potential at point P?

$$V_1 = \frac{kQ_1}{r_1}$$
$$= \frac{9.0\times10^9 \cdot 7.5\times10^{-6}}{(0.20\text{ m} + 0.15\text{ m})}$$
$$= 1.93\times10^5\text{ V} \quad \leftarrow \textbf{2 marks}$$

$$V_2 = \frac{kQ_2}{r_2}$$
$$= \frac{(9.0\times10^9)(-2.5\times10^{-6}\text{ C})}{(0.15\text{ m})}$$
$$= -1.50\times10^5\text{ V} \quad \leftarrow \textbf{2 marks}$$

$$V_p = V_1 + V_2$$
$$= 1.93\times10^5\text{ V} + -1.50\times10^5\text{ V} \quad \leftarrow \textbf{2 marks}$$
$$= 4.3\times10^4\text{ V} \quad \leftarrow \textbf{1 mark}$$

6.

Using principles of physics, describe the electric field along the line from Q_1 to Q_2. **(4 marks)**

The electric field initially points to the right and decreases as you move along the line.
At one point, closer to Q_1, the electric field will be zero.
Past this point, the field is pointing to the left and increases.

7. a) The electron beam is produced by accelerating electrons through an electric potential difference of 380 V. What is the speed of the electrons as they leave the 380 V plate? **(3 marks)**

$$\Delta E_k = \Delta E_p$$
$$\frac{1}{2}mv^2 = QV_a$$
$$\therefore v = \left(\frac{2QV}{m}\right)^{\frac{1}{2}}$$
$$= \left(\frac{2\cdot1.6\times10^{-19}\cdot380}{9.11\times10^{-31}}\right)^{\frac{1}{2}}$$
$$= 1.2\times10^7\text{ m/s} \quad \leftarrow \textbf{3 marks}$$

b) What is the electrostatic force on electrons in the region between the horizontal plates when they are connected to a 9.0 V potential difference? **(4 marks)**

$$E_{plates} = \frac{V}{d}$$
$$= \frac{9.0}{0.020}$$
$$= 4.5\times10^2\text{ V/m} \quad \leftarrow \textbf{2 marks}$$

$$\therefore F_E = qE$$
$$= 1.6\times10^{-19}\cdot4.50\times10^2 \quad \leftarrow \textbf{2 marks}$$
$$= 7.2\times10^{-17}\text{ N}$$

8.

$$V_p = \frac{kQ}{R_1}$$
$$= \left(\frac{9.00\times10^{9}\cdot 2.0\times10^{-7}}{0.50}\right) \quad \left.\right\} \leftarrow \textbf{2 marks}$$
$$= 3\,600 \text{ V}$$

$$V_R = \frac{kQ}{R_2}$$
$$= \left(\frac{9.00\times10^{9}\cdot 2.0\times10^{-7}}{0.40}\right) \quad \left.\right\} \leftarrow \textbf{2 marks}$$
$$= 4\,500 \text{ V}$$

$$\therefore \Delta V_{PR} = V_p - V_R = 4\,500 - 3\,600 \quad \leftarrow \textbf{2 marks}$$

$$= \pm 900 \text{ V} \quad \leftarrow \textbf{1 mark}$$

9.

a) Find the magnitude of the acceleration of the helium nucleus due to these plates. **(5 marks)**

$$a = \frac{F}{m} \qquad F = qE \qquad E = \frac{V}{d}$$

$$a = \frac{qV}{md} \quad \leftarrow \textbf{3 marks}$$

$$= \frac{2\times1.6\times10^{-19}\times230}{4\times1.67\times10^{-27}\times0.12} \quad \leftarrow \textbf{1 mark}$$

$$= 9.2\times10^{10} \text{ m/s}^2 \quad \leftarrow \textbf{1 mark}$$

b) A proton travelling at the same velocity as the helium nucleus is then sent through these same plates. Explain, using principles of physics, why the acceleration of the proton is larger than that of the helium nucleus. **(4 marks)**

A proton has one quarter of the mass and one half of the charge of a helium nucleus. ← **2 marks**

The proton will have twice the acceleration of the helium nucleus: $a \propto \frac{q}{m}$. ← **2 marks**