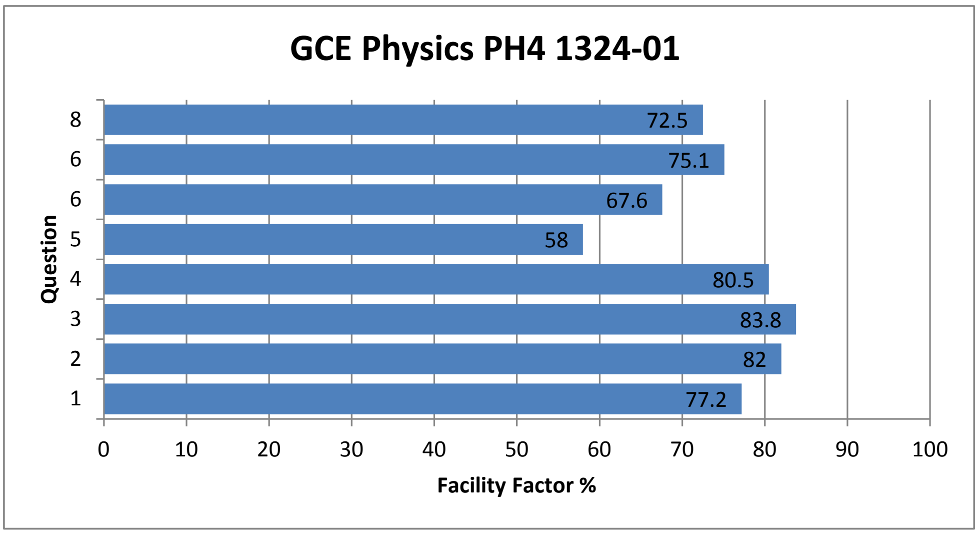
WJEC 2014 Online Exam Review

GCE Physics PH4 1324-01

All Candidates' performance across questions

Question Title	*N*	*Mean*	*S D*	*Max Mark*	*F F*	*Attempt %*	
1	1097	9.3	3.3	12	77.2	100	
2	1097	6.6	2.3	8	82	100	
3	1095	4.2	1.2	5	83.8	99.8	
4	1096	9.7	2.6	12	80.5	99.9	
5	1095	5.8	2.9	10	58	99.8	5
6	1096	8.1	2.8	12	67.6	99.9	6
6	1096	7.5	2.3	10	75.1	99.9	
8	1090	8	2.6	11	72.5	99.4	8



Examiner only

5. *(a)* Define:

(i) the gravitational field strength at a point; [1]

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(ii) the gravitational potential at a point. [1]

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(b) Charon is the moon of Pluto; it has a mass of 1.5×10^{21} kg and its radius is 600 km.

(i) Calculate the gravitational force exerted by Charon on an object of mass 82 kg on its surface. [2]

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(ii) Calculate the gravitational potential energy of the 82 kg mass on Charon's surface (you may ignore Pluto). [2]

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Examiner only

(c) Pluto has a mass of 1.3×10^{22} kg and radius of 1150 km. Calculate the potential energy of the 82 kg mass if it were on the surface of Pluto (you may ignore Charon). [2]

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(d) The 82 kg mass is fired from Charon's surface to Pluto. Neglecting any losses due to resistive forces, calculate the change in kinetic energy of the 82 kg mass from the instant it was fired to the instant just before it collides with Pluto. [2]

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The (force acting per unit mass at a point Resultant.

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The work done in bringing unit mass ~~the~~ from infinity (∞) to that point.

(b) Charon is the moon of Pluto; it has a mass of 1.5×10^{21} kg and its radius is 600 km.

(i) Calculate the gravitational force exerted by Charon on an object of mass 82 kg on its surface. [2]

$F = G\frac{m_1 m_2}{r^2} = 6.67 \times 10^{-11} \times \frac{1.5 \times 10^{21} \times 82}{(600 \times 10^3)^2} = 22.8\ N$

(ii) Calculate the gravitational potential energy of the 82 kg mass on Charon's surface (you may ignore Pluto). [2]

$V_g = \frac{-GM}{r} = \frac{-6.67 \times 10^{-11} \times 1.5 \times 10^{21}}{600 \times 10^3} = -1.67 \times 10^{6}$

$= 1.67 \times 10^{6}\ J$

(c) Pluto has a mass of 1.3×10^{22} kg and radius of 1150 km. Calculate the potential energy of the 82 kg mass if it were on the surface of Pluto (you may ignore Charon). [2]

$$V_g = \frac{-6.67 \times 10^{-11} \times 1.3 \times 10^{22}}{1150 \times 10^{3}} = -7.54 \times 10^{5}\ J$$

$$= 7.54 \times 10^{5}\ J$$

(d) The 82 kg mass is fired from Charon's surface to Pluto. Neglecting any losses due to resistive forces, calculate the change in kinetic energy of the 82 kg mass from the instant it was fired to the instant just before it collides with Pluto. [2]

$$1.67 \times 10^{6} - 7.54 \times 10^{5} = \tfrac{1}{2}mv^2 = 9.16 \times 10^{5}\ J$$

$$v = \sqrt{\frac{2 \times 9.6 \times 10^{5}}{82}} = 153\ ms^{-1}$$

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only

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The force per kg that is ~~action~~ acting ~~on~~ on an object ~~for~~ from a given point

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$$F = \frac{GM_1M_2}{r^2} = \frac{6.67\times10^{-11} \times 1.5\times10^{21} \times 82}{(600\times10^3)^2}$$

$$F = \cancel{22.78916667\ N}\ 2278.916667\ N$$

(ii) Calculate the gravitational potential energy of the 82 kg mass on Charon's surface (you may ignore Pluto). [2]

$$V_g = \frac{-GM}{r} = \frac{-6.67\times10^{-11} \times \cancel{82}\ 1.5\times10^{21}}{600\times10^3} = \cancel{-9.115666667\times10^{-15}}$$

$$= \cancel{-9.12\times10^{-15}\ \text{J kg}^{-1}}$$

$$= -166750\ \text{J kg}^{-1}$$

(c) Pluto has a mass of 1.3×10^{22} kg and radius of 1150 km. Calculate the potential energy of the 82 kg mass if it were on the surface of Pluto (you may ignore Charon). [2]

$V_g = -\frac{GM}{r} = -\frac{6.67 \times 10^{-11} \times 1.3 \times 10^{22}}{1150 \times 10^3} = -754000 \text{ J kg}^{-1}$

(d) The 82 kg mass is fired from Charon's surface to Pluto. Neglecting any losses due to resistive forces, calculate the change in kinetic energy of the 82 kg mass from the instant it was fired to the instant just before it collides with Pluto. [2]

~~$\Delta V_g = -754000 \text{ J kg}^{-1}$ as V_g of Charon is negligible compared to V_g of Pluto~~ $\Delta V_g = -920750$ J

$W = m\Delta V_g = 82 \times \cancel{-784000} -920750$

~~$= -61828000$ J~~

$= -75501500$ J

$= -7.55 \times 10^7$ J

only

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$F = \cancel{22\ 78916667\ N}$ 2278.916667 N

(ii) Calculate the gravitational potential energy of the 82 kg mass on Charon's surface (you may ignore Pluto). [2]

$V_g = \frac{-GM}{r} = \frac{-6.67\times10^{-11} \times 1.5\times10^{21}}{600\times10^3} = \cancel{-9.4\ 5666667\times10^{-15}}$

$= \cancel{-9.4\ 12\times10^{-15}}\ \text{J kg}^{-1}$

$= -166750\ \text{J kg}^{-1}$

(c) Pluto has a mass of 1.3×10^{22} kg and radius of 1150 km. Calculate the potential energy of the 82 kg mass if it were on the surface of Pluto (you may ignore Charon). [2]

$V_g = -\frac{GM}{r} = -\frac{6.67\times10^{-11} \times 1.3\times10^{22}}{1150\times10^{3}} = -754\,000 \text{ J kg}$

(d) The 82 kg mass is fired from Charon's surface to Pluto. Neglecting any losses due to resistive forces, calculate the change in kinetic energy of the 82 kg mass from the instant it was fired to the instant just before it collides with Pluto. [2]

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~~force acting~~ work done
~~work done~~ ~~for~~ bring a unit mass
From infinity to a certain point ~~in~~
~~a grav~~

(ii) the gravitational potential at a point. [1]

work done to bring a unit mass
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$F = \frac{GMm}{r^2} = 6.67 \times 10^{-11} \times \frac{1.5 \times 10^{21} \times 82}{(600 \times 10^3)^2} =$

$22.79\,N$

(ii) Calculate the gravitational potential energy of the 82 kg mass on Charon's surface (you may ignore Pluto). [2]

$V = \frac{GM}{r}$ $\quad \frac{1.5 \times 10^{21} \times 6.67 \times 10^{-11}}{600 \times 10^3} = 166750$

$P.E = m \times V$

$166750 \times 82 = 13.67 \times 10^6 \ J\,kg^{-1}$

(c) Pluto has a mass of 1.3×10^{22} kg and radius of 1150 km. Calculate the potential energy of the 82 kg mass if it were on the surface of Pluto (you may ignore Charon). [2]

$E_p = \frac{GMm}{r}$

$\frac{1.3 \times 10^{22} \times 82 \times 6.67 \times 10^{-11}}{1150 \times 10^{3}} = 61.83 \times 10^{6}$ J

(d) The 82 kg mass is fired from Charon's surface to Pluto. Neglecting any losses due to resistive forces, calculate the change in kinetic energy of the 82 kg mass from the instant it was fired to the instant just before it collides with Pluto. [2]

$61.83 \times 10^{6} - 13.67 \times 10^{6} = 48.16 \times 10^{6}$

48.16×10^{6} J

only

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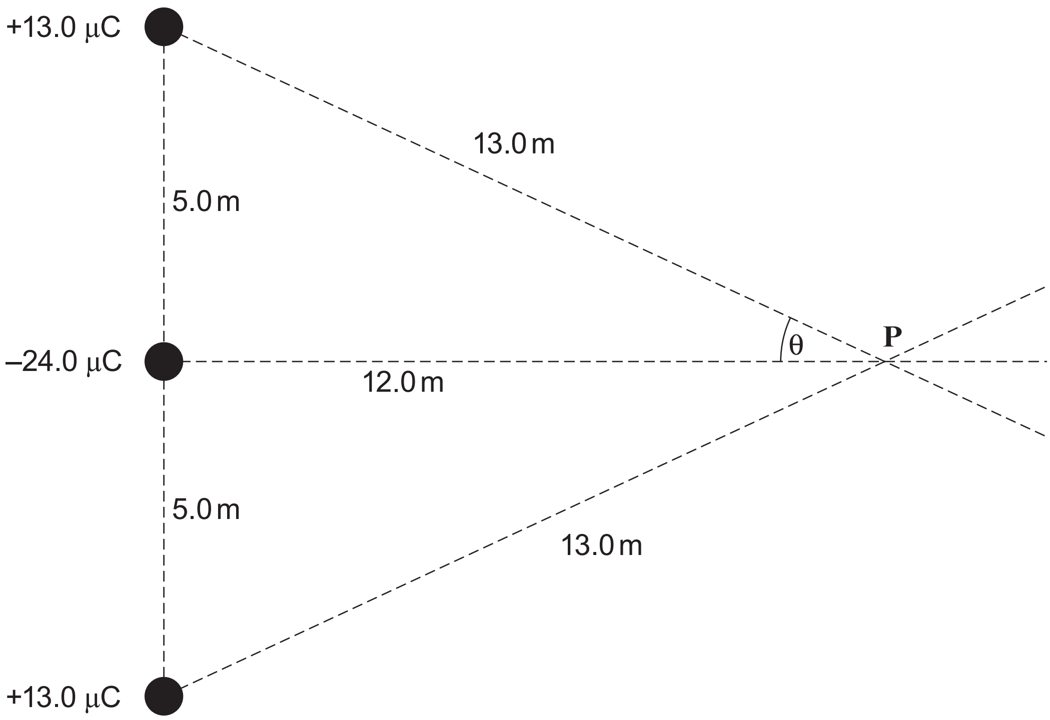
$48.16\times10^{6}\,J$

Examiner only

6. Three charges are arranged as shown.



(a) **Draw three arrows at P** to represent the electric fields due to **each** of the three charges. [2]

(b) Calculate the electric field strength at **P** due to the –24.0 μC charge only (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{F^{-1}\ m}$). [2]

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Examiner only

(c) Calculate the resultant electric field strength at **P** (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{F}^{-1}\ \text{m}$). [3]

(d) Show that the electric potential at **P** is zero. [2]

(e) A negative charge is released from rest at point **P** and encounters **no resistive forces.** Explain in terms of energy and forces why the charge initially accelerates to the right but eventually becomes stationary a long way away from the three charges. [3]

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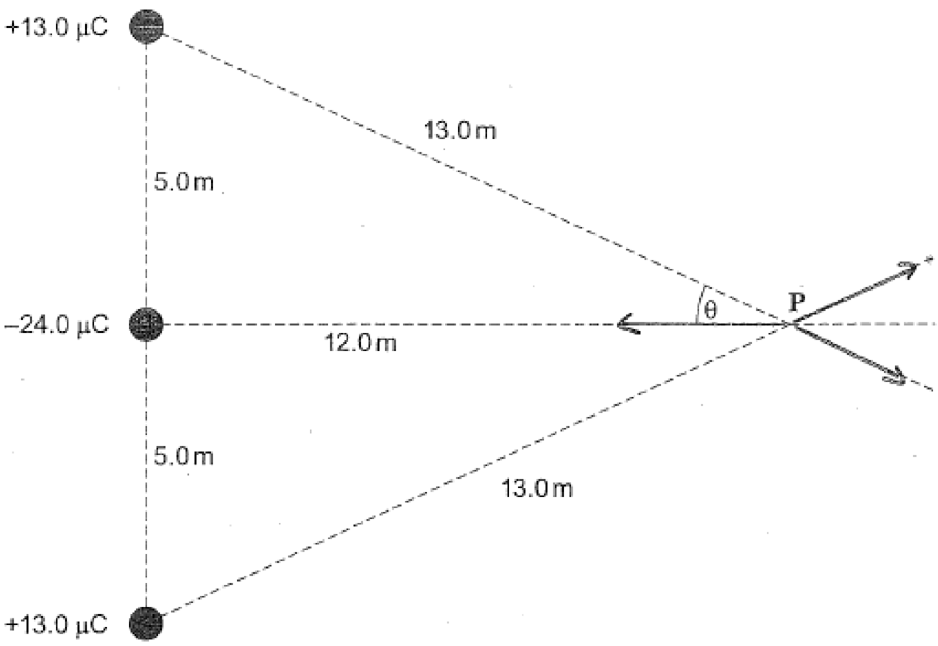

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$F = \cancel{}\ 9\times10^9 \times \frac{-24\times10^{-6}}{12} = -18000$ (negative indicates direction.)

$= 18000\ V$

(c) Calculate the resultant electric field strength at **P** (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ F^{-1}\ m$). [3]

$\sin\theta = \frac{5}{13}$ 5, 12, 13

$F = 9\times10^9 \frac{13\times10^{-6}}{13} = 9000\ V$

22.62

$c = \frac{a}{h}$

$2 \times \left(9000 \times \frac{12}{13}\right) =$ 16615.4 V →

$2 \times (9000 \times \cos\theta) =$

16615.4 − 1384.6 ←

− 18000 = V

(towards −24 μC charge)

(d) Show that the electric potential at **P** is zero. [2]

$V_E = 9\times10^9 \left(2\times \frac{13\times10^{-6}}{13} + \frac{-24\times10^{-6}}{12}\right) = 0\ J$

(e) A negative charge is released from rest at point **P** and encounters **no resistive forces.** Explain in terms of energy and forces why the charge initially accelerates to the right but eventually becomes stationary a long way away from the three charges. [3]

Repeled at first by resultant force due to −24.0 μC then as it moves further away θ gets smaller and therefore the resultant force due to the positive charges predominate and forces balance, because loss KE overcoming force.

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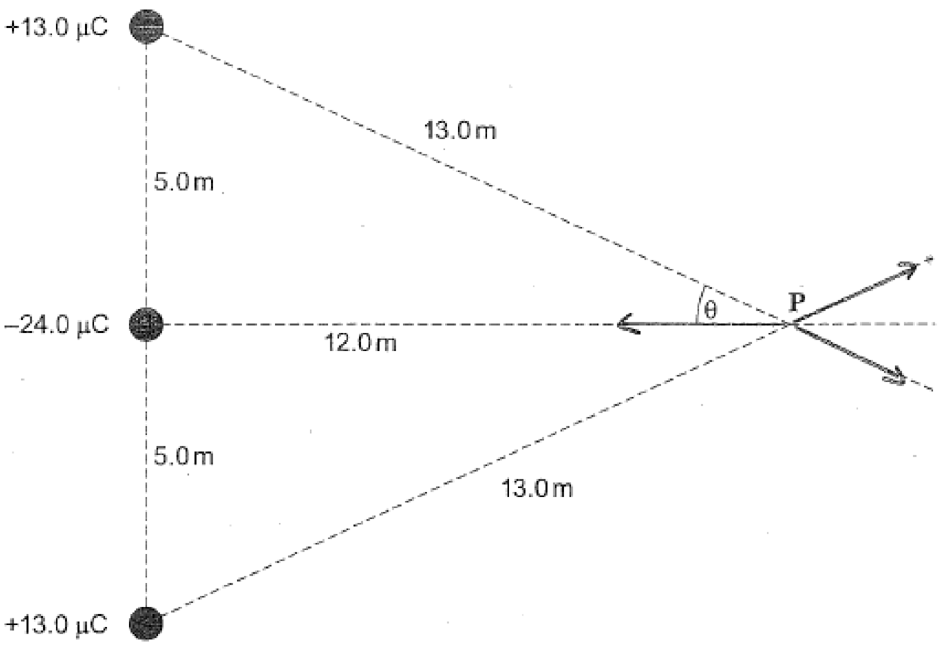

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~~[illegible]~~ − 18000 = ~~[illegible]~~ V

(towards −24 μC charge)

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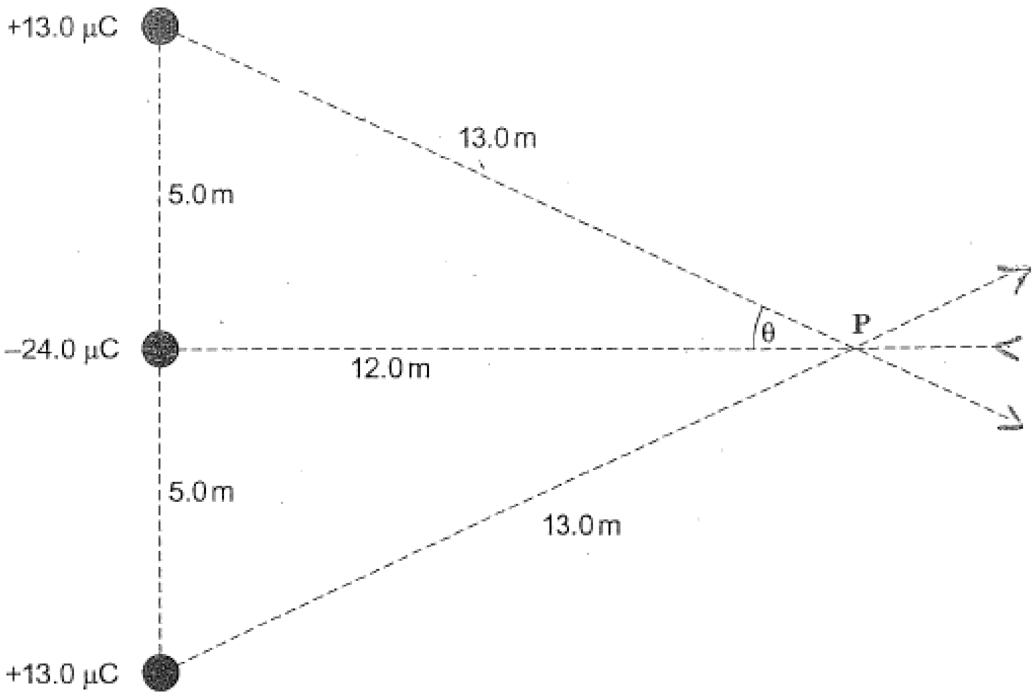

(a) **Draw three arrows at P** to represent the electric fields due to **each** of the three charges. [2]

(b) Calculate the electric field strength at **P** due to the −24.0 μC charge only (you may use the approximation $\frac{1}{4\pi\varepsilon_0}$ = 9 × 10^9 F^{-1} m). [2]

$E = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{r^2} = 9\times10^9 \times \frac{-24\times10^{-6}}{(12)^2}$

$= \cancel{-2500}$ ~~CmF^{-1}~~

$= -1500\ Vm^{-1}$

only

(c) Calculate the resultant electric field strength at **P** (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{F}^{-1}\ \text{m}$). [3]

$\cos\theta = \frac{12}{13}$ $\theta = 22.61986495$

$E = 9\times10^9 \times \frac{Q}{r^2} \times 2 = 2\times9\times10^9 \times \frac{13\times10^{-6} \times \cos 22.6}{(13)^2}$

$= 1278.106509$

$\Delta E = 1278 + -1500 = -221.8934911$

$\Delta E = -221.9\ \text{Vm}^{-1}$

(d) Show that the electric potential at **P** is zero. [2]

~~$2V_E = 2\times9\times10^9 \times \frac{13\times10^{-6}\times\cos 22.6}{13} = 16615.38462\ \text{V}$~~

~~$V_E = 9\times10^9\ (\frac{-24\times10^{-6}}{12})$~~ =

Show vertically $Q = -24\times10^{-6}$ & $V_E = 0\ \text{V}$

as it is already in the centre

$\Delta V_E = 9\times10^9 \times \frac{13\times10^6}{5} - 9\times10^9 \times \frac{13\times10^6}{5} = 0\ \text{V}$

(e) A negative charge is released from rest at point **P** and encounters **no resistive forces.** Explain in terms of energy and forces why the charge initially accelerates to the right but eventually becomes stationary a long way away from the three charges. [3]

The ~~negater~~ negative charge is reppelled ~~by~~ from point P as it's energy is -ve, is it's speed keeps increasing, as there are no resistive forces, until it reaches it's terminal velocity. until eventually it gets close to infinity, which is also a -ve charge, and it decelerates until it stops

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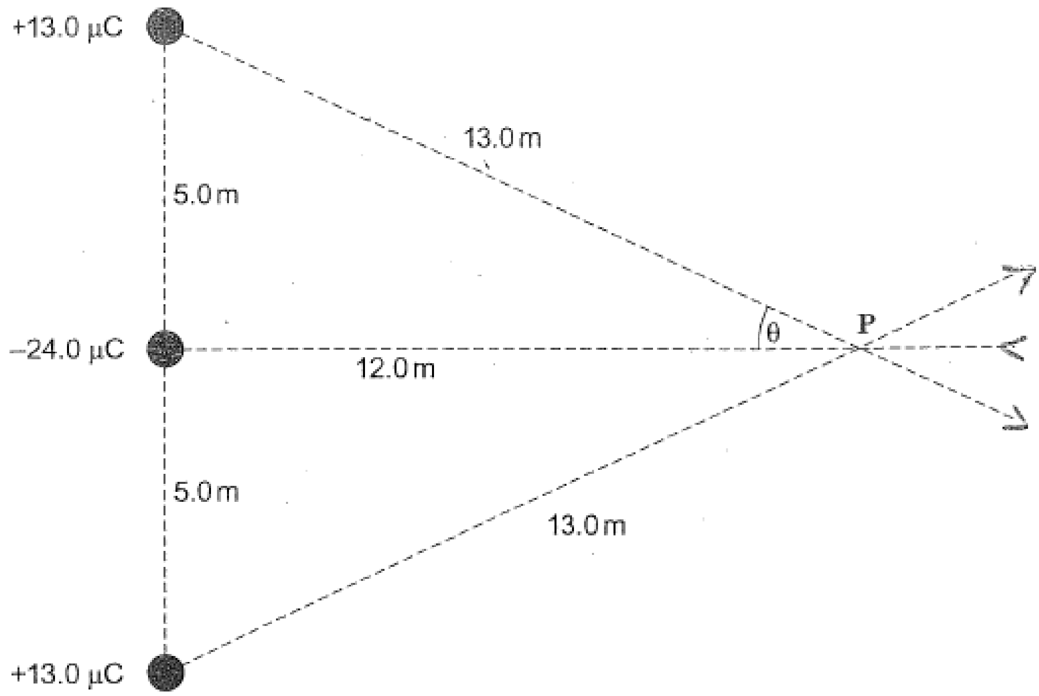

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$E = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{r^2} = 9\times10^9 \times \frac{-24\times10^{-6}}{(12)^2}$

$= -1500\ \mathrm{CmF^{-1}}$

$= -1500\ \mathrm{Vm^{-1}}$

only

(c) Calculate the resultant electric field strength at **P** (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{F}^{-1}\ \text{m}$). [3]

$\cos\theta = \frac{12}{13}$ $\theta = 22.61986495$

$E = 9\times10^9 \times \frac{Q}{r^2} \times 2 = 2\times 9\times10^9 \times \frac{13\times10^{-6} \times 12}{13(13)^2}$ Cos 22.6

$= 1278.106509$

$\Delta E = 1278 + {-1500} = -221.8934911$

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(d) Show that the electric potential at **P** is zero. [2]

~~$2V_E = 2\times 9\times10^9 \times \frac{13\times10^{-6} \times \cos 22.6}{13} = 16615.38462\ V$~~

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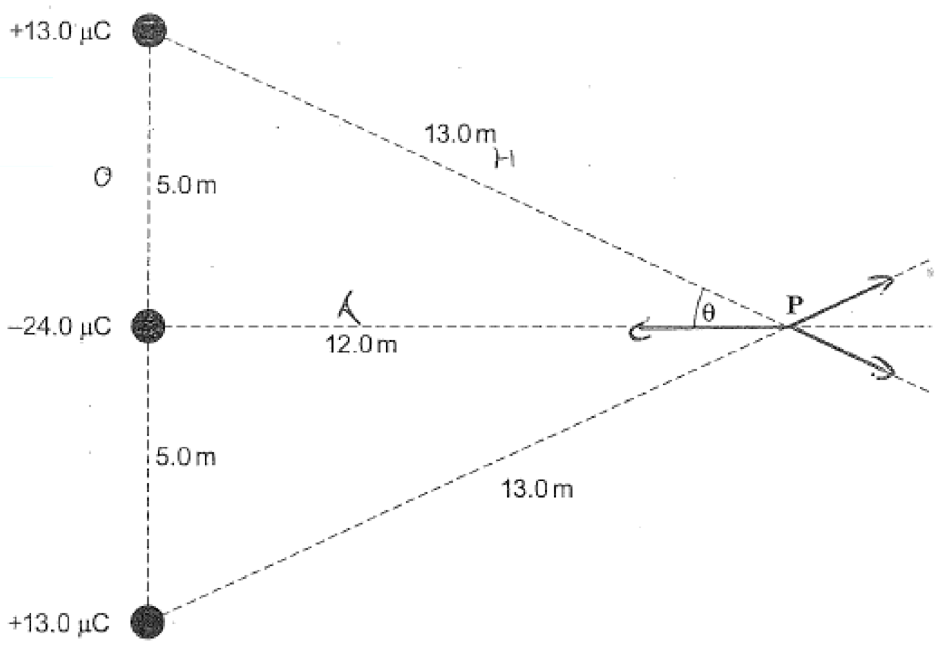

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(b) Calculate the electric field strength at **P** due to the −24.0 µC charge only (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{F^{-1}\ m}$). [2]

$\frac{13\times10^{-6}}{13^2} \times 9\times10^9 = 622.3 \times 2$

$\frac{24\times10^{-6}}{12^2} \times 9\times10^9 = -1500$ $\quad 622.3 \times 2 - 1500 = -255.4$

$-255.4\ \mathrm{NC^{-1}}$

(c) Calculate the resultant electric field strength at P (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ F^{-1}\ m$). [3]

$\theta = \sin^{-1}\left(\frac{5}{13}\right) = 22.62°$

$\cos(22.62) \times 622.3 = 574.4 \quad \times 2$

~~[illegible]~~ 1148.8

$1148.8 - 1500 = -351.2\ NC^{-1}$

(d) Show that the electric potential at P is zero. [2]

$V = $ ~~[illegible]~~ $9 \times 10^9 \times \frac{Q}{r} = 9000$

$9000 \times 2 = 18000$

$\frac{-24 \times 10^{-6}}{12} \times 9 \times 10^9 = -18000$

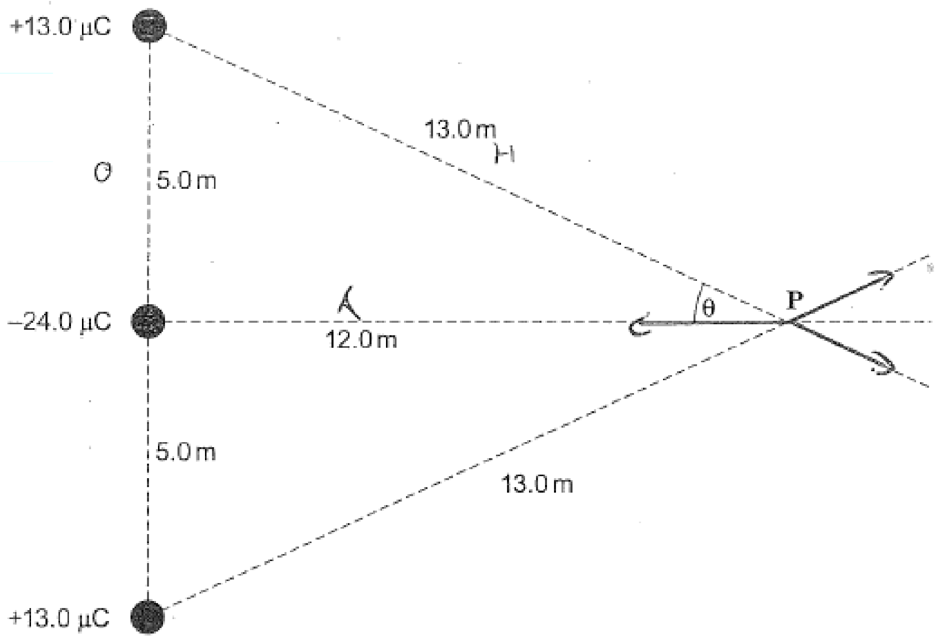
$18000 - 18000 = 0\ JC^{-1}$

(e) A negative charge is released from rest at point P and encounters **no resistive forces.** Explain in terms of energy and forces why the charge initially accelerates to the right but eventually becomes stationary a long way away from the three charges. [3]

When the negative charge is released the field on the left repells it to the right. A long distance away the distance between the three charges are negligible, meaning that their forces cancel out ~~[illegible] and the electric potentia~~ as they ~~[illegible]~~ and nothing will repell them to the right anymore.

A field from the right will slow the charge down

6. Three charges are arranged as shown.



(a) **Draw three arrows at P** to represent the electric fields due to **each** of the three charges. [2]

(b) Calculate the electric field strength at **P** due to the −24.0 μC charge only (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{F^{-1}\ m}$). [2]

$\frac{13\times10^{-6}}{13^2} \times 9\times10^9 = 622.3 \times 2$

$\frac{24\times10^{-6}}{12^2} \times 9\times10^9 = -1500$ $\quad 622.3 \times 2 - 1500 = -255.4$

$-255.4\ \mathrm{NC^{-1}}$

(c) Calculate the resultant electric field strength at **P** (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ F}^{-1} \text{ m}$). [3]

$\theta = \sin^{-1}\left(\frac{5}{13}\right) = 22.62^\circ$

$\cos(22.62) \times 622.3 = 574.4 \quad \times 2$

1148.8

$1148.8 - 1500 = -351.2 \text{ N C}^{-1}$

(d) Show that the electric potential at **P** is zero. [2]

$V = \frac{GM}{r} \quad 9 \times 10^9 \times \frac{Q}{r} = 9000$

$9000 \times 2 = 18000$

$\frac{-24 \times 10^{-9}}{12} \times 9 \times 10^9 = -18000$

$18000 - 18000 = 0 \text{ J C}^{-1}$

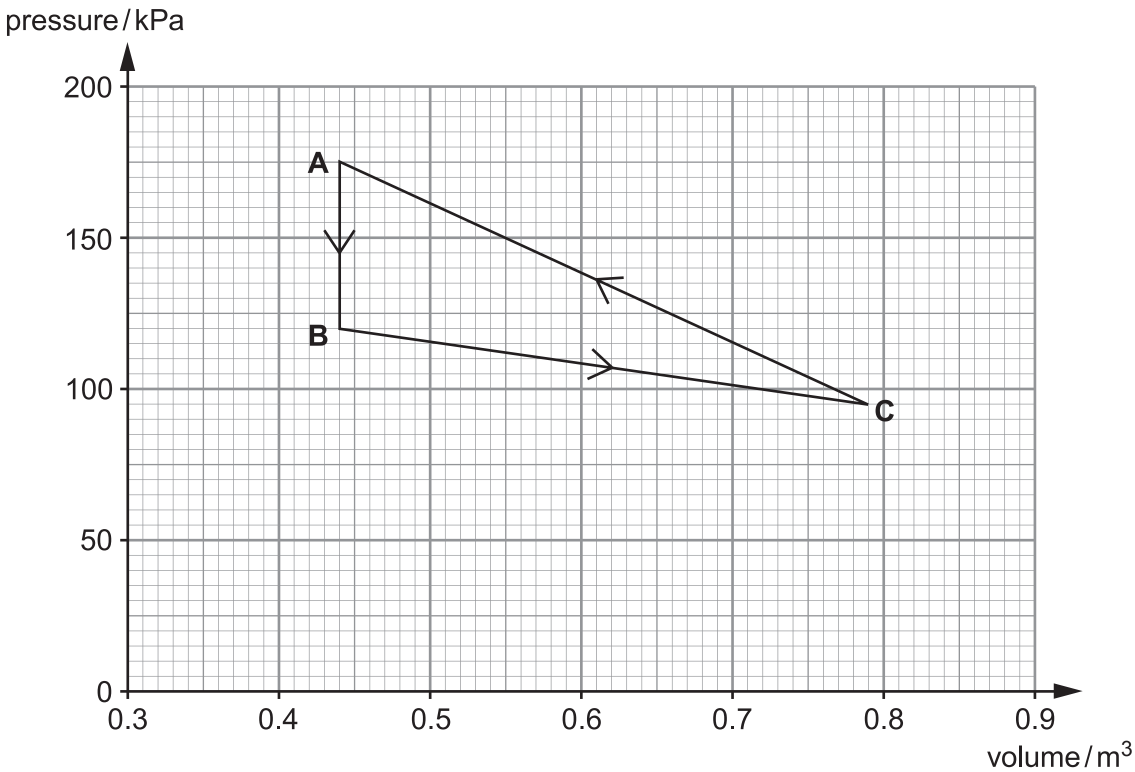
(e) A negative charge is released from rest at point **P** and encounters **no resistive forces.** Explain in terms of energy and forces why the charge initially accelerates to the right but eventually becomes stationary a long way away from the three charges. [3]

When the negative charge is released the field on the left repells it to the right. A long distance away the distance between the three charges are negligible, meaning that their forces cancel out ~~and the electric potential~~ as they ~~cancle~~ and nothing will repell them to the right anymore.

A field from the right will slow the charge down

Examiner only

8. A sample of an ideal monatomic gas is taken through the closed cycle **ABCA** as shown.



(a) There are **28.9 mol** of gas. The temperatures of points **A** and **B** are 321 K and 220 K respectively.

(i) Show that the temperature of **C** is 313 K. [2]

....

....

....

(ii) Calculate the change in internal energy, ΔU, for **AB**. [2]

....

....

....

....

....

Examiner only

(b) Determine the work done **by** the gas, W, for:

(i) **AB**; [1]

....

(ii) **CA**. [2]

....

....

....

....

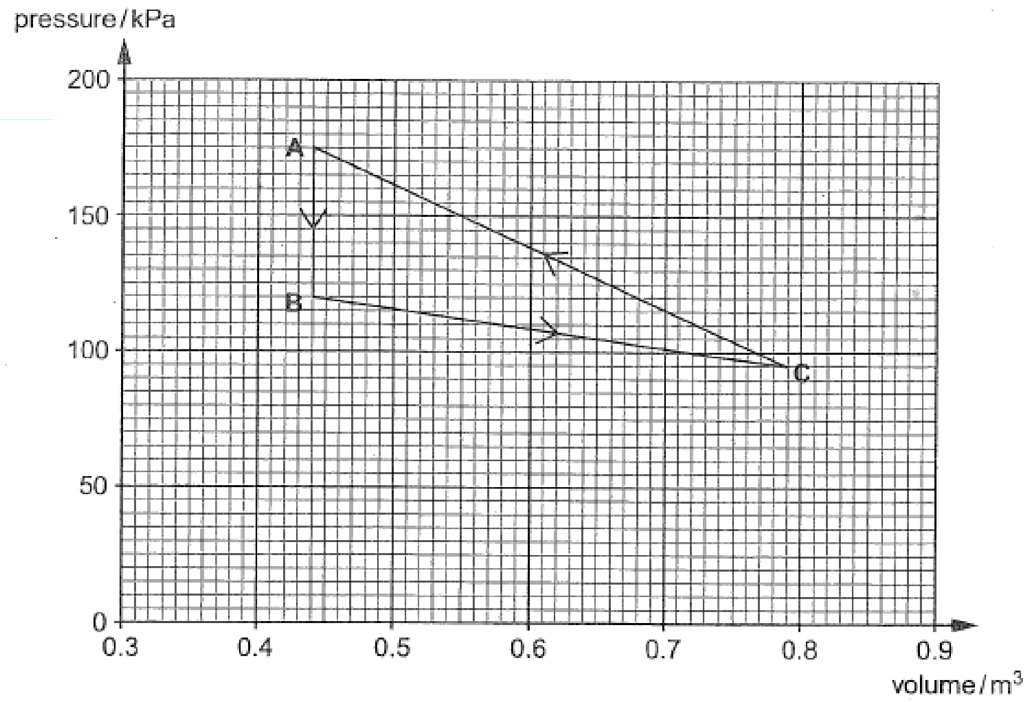
(c) For **each** of the processes **AB**, **BC**, **CA** and the whole cycle **ABCA**, write the values of W (the work done by the gas), ΔU (the change in internal energy of the gas) and Q (the heat supplied to the gas). The numbers in bold have been added to save time with repeated calculations. [4]

	Process			
	AB	**BC**	**CA**	**ABCA**
W		**37.6 kJ**		
ΔU		**33.5 kJ**	**2.9 kJ**	
Q				

Space for calculations:

END OF PAPER

8. A sample of an ideal monatomic gas is taken through the closed cycle **ABCA** as shown.



(a) There are **28.9 mol** of gas. The temperatures of points **A** and **B** are 321 K and 220 K respectively.

(i) Show that the temperature of **C** is 313 K. [2]

$\frac{0.44 \times 175}{321} = \frac{0.79 \times 95}{T}$

$T = \frac{0.79 \times 95 \times 321}{0.44 \times 175} = 312.87 \approx 313\ K$

(ii) Calculate the change in internal energy, ΔU, for **AB**. [2]

$\Delta U = Q - W$ ~~$W = 0$~~

~~$\Delta U = Q$~~ $Q =$ ~~101~~

~~$\Delta U = 401\ J$~~

$U = \frac{3}{2} nRT$ $\Delta U = \frac{3}{2} \times 28.4 \times 831 (101) = 35.6\ KJ$

(b) Determine the work done **by** the gas, W, for:

(i) **AB**; [1]

0 no change in volume.

(ii) **CA**. [2]

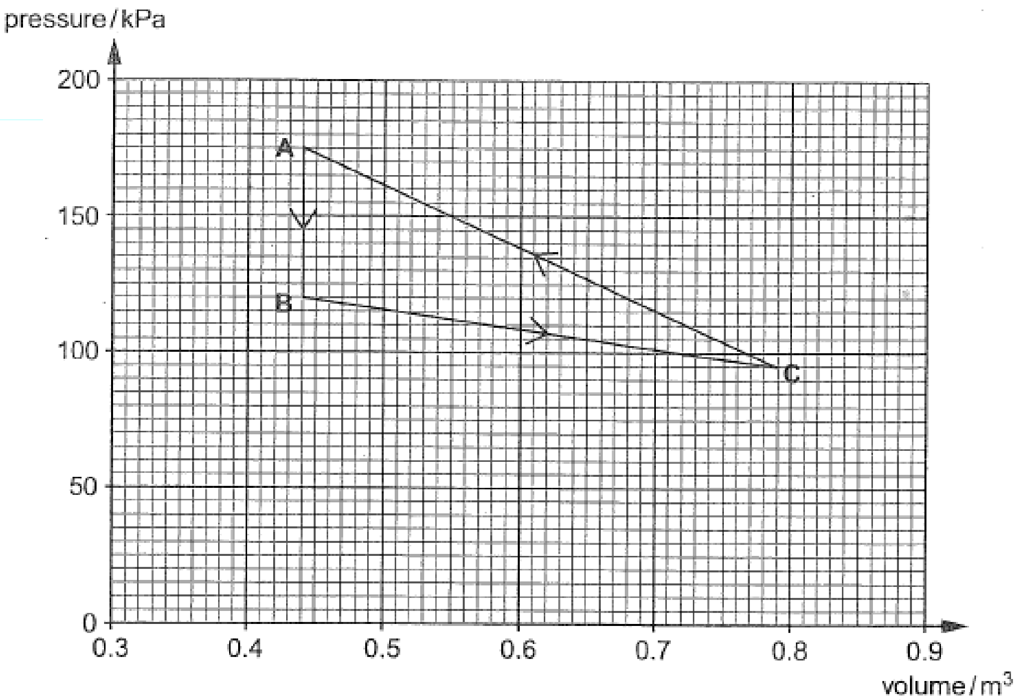
$W = p\Delta V$ = Area under graph

$\left(\frac{175 + 95}{2}\right) \times (0.79 - 0.44) = 47.25$ kJ

(c) For **each** of the processes **AB**, **BC**, **CA** and the whole cycle **ABCA**, write the values of W (the work done by the gas), ΔU (the change in internal energy of the gas) and Q (the heat supplied to the gas). The numbers in bold have been added to save time with repeated calculations. [4]

	Process			
	AB	BC	CA	ABCA
W	0	**37.6 kJ**	47.25	~~84.85~~
ΔU	35.6 kJ	**33.5 kJ**	**2.9 kJ**	0
Q	35.6 kJ	71.1 kJ	50.2 kJ	~~157.3~~

8. A sample of an ideal monatomic gas is taken through the closed cycle **ABCA** as shown.



(a) There are **28.9 mol** of gas. The temperatures of points **A** and **B** are 321 K and 220 K respectively.

(i) Show that the temperature of **C** is 313 K. [2]

$\frac{0.44\times175}{321} = \frac{0.79\times95}{T}$

$T = \frac{0.79\times95\times321}{0.44\times175} = 312.87 \approx 313$ K

(ii) Calculate the change in internal energy, ΔU, for **AB**. [2]

$\cancel{\Delta U = Q - W}$ $\cancel{W = 0}$

$\cancel{\Delta U = Q}$ $Q = \cancel{101}$

$\Delta U = 401$ J

$U = \frac{3}{2}nRT$ $\Delta U = \frac{3}{2}\times28.4\times8.31(101) = 35.6$ KJ

(b) Determine the work done **by** the gas, W, for:

(i) **AB**; [1]

0 no change in volume.

(ii) **CA**. [2]

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$\left(\frac{175 + 95}{2}\right) \times (0.79 - 0.44) = 47.25$ kJ

(c) For **each** of the processes **AB**, **BC**, **CA** and the whole cycle **ABCA**, write the values of W (the work done by the gas), ΔU (the change in internal energy of the gas) and Q (the heat supplied to the gas). The numbers in bold have been added to save time with repeated calculations. [4]

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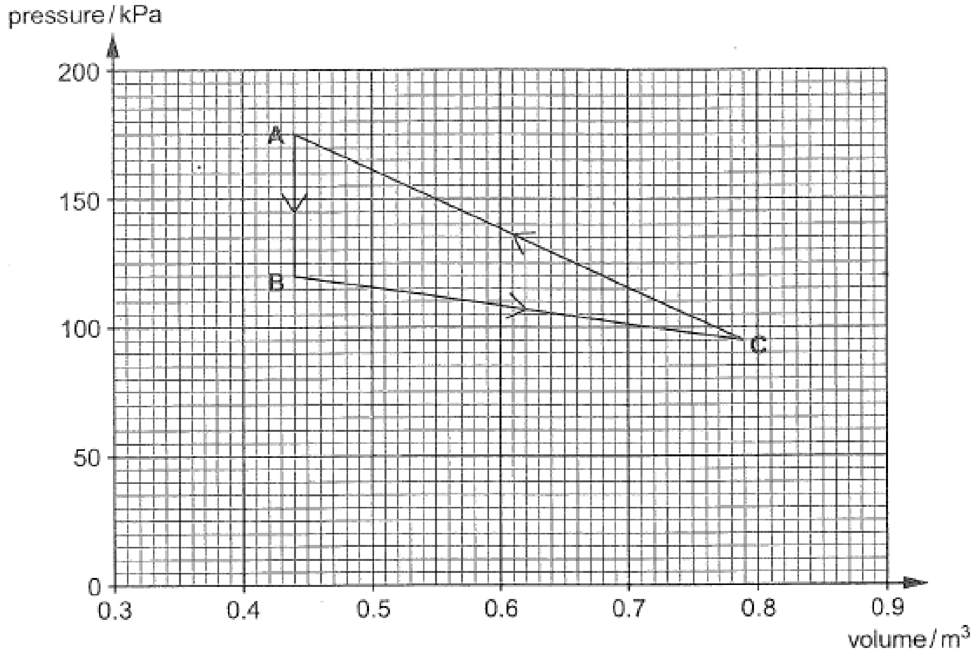


(a) There are **28.9 mol** of gas. The temperatures of points **A** and **B** are 321 K and 220 K respectively.

(i) Show that the temperature of **C** is 313 K. [2]

$\frac{pV}{nR} = T = \frac{95 \times 10^3 \times 0.79}{\cancel{9.85}\ 28.9 \times 8.31} = 312.5013012$

$= 312.5\ K$

(ii) Calculate the change in internal energy, ΔU, for **AB**. [2]

$\Delta U = \frac{3}{2} nR\Delta T$ $\quad T_B = \frac{120 \times 10^3 \times 0.44}{28.9 \times 8.31} = 219.8543465\ K$

$T_{\cancel{B}A} = \frac{175 \times 10^3 \times 0.44}{28.9 \times 8.31} = 320.6209022\ K$

$\Delta U = \frac{3}{2} \times 28.9 \times 8.31 \times (320.6 - 219.9) = \underline{36300\ J}$

(b) Determine the work done **by** the gas, W, for:

(i) **AB**; [1]

0 J

(ii) **CA**. [2]

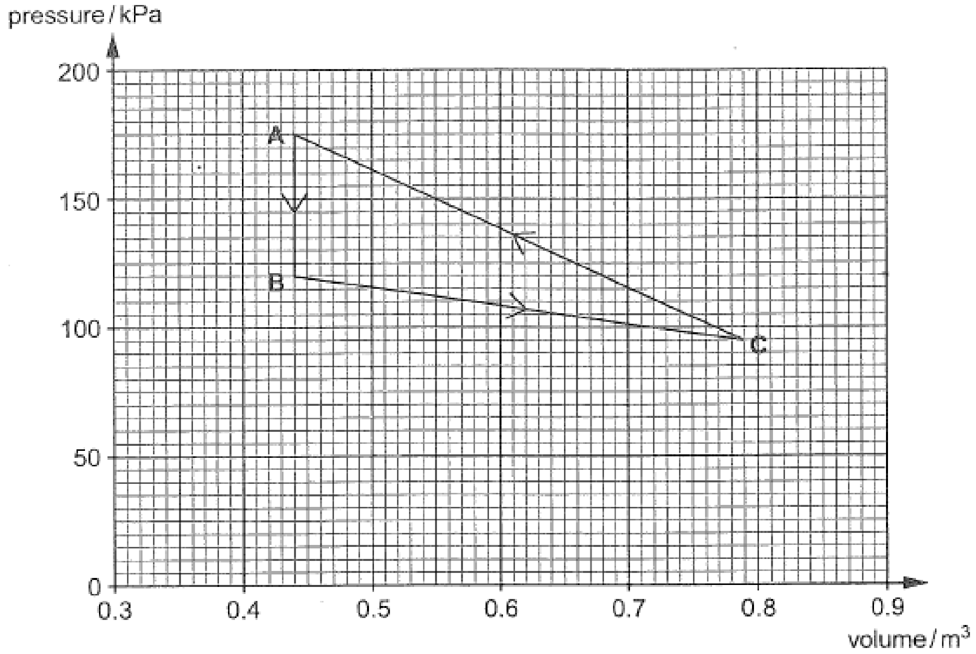
$W = \frac{1}{2}ab = \frac{1}{2}(175\times10^3 - 95\times10^3)(0.44 - 0.79)$

$= -14000$ J

(c) For **each** of the processes **AB**, **BC**, **CA** and the whole cycle **ABCA**, write the values of W (the work done by the gas), ΔU (the change in internal energy of the gas) and Q (the heat supplied to the gas). The numbers in bold have been added to save time with repeated calculations. [4]

	Process			
	AB	BC	CA	ABCA
W	0 J	**37.6 kJ**	−14 kJ	23.6 kJ
ΔU	36.3 kJ	**33.5 kJ**	**2.9 kJ**	72.7 kJ
Q	36.3 kJ	71.1 kJ	−11.1 kJ	96.3 kJ

8. A sample of an ideal monatomic gas is taken through the closed cycle **ABCA** as shown.



(a) There are **28.9 mol** of gas. The temperatures of points **A** and **B** are 321 K and 220 K respectively.

(i) Show that the temperature of **C** is 313 K. [2]

$\frac{PV}{nR} = T = \frac{95\times10^3 \times 0{\cdot}79}{\cancel{985}\ 28{\cdot}9\times8{\cdot}31} = 312{\cdot}5013012$

$= 312{\cdot}5\ K$

(ii) Calculate the change in internal energy, ΔU, for **AB**. [2]

$\Delta U = \frac{3}{2} nR\Delta T$ $\quad T_B = \frac{120\times10^3 \times 0{\cdot}44}{28{\cdot}9 \times 8{\cdot}31} = 219{\cdot}8543465\ K$

$T_{A} = \frac{175\times10^3 \times 0{\cdot}44}{28{\cdot}9\times8{\cdot}31} = 320{\cdot}620922\ K$

$\Delta U = \frac{3}{2} \times 28{\cdot}9 \times 8{\cdot}31 \times (320{\cdot}6 - 219{\cdot}9) = \underline{36300\ J}$

(b) Determine the work done **by** the gas, W, for:

(i) **AB**; [1]

0 J

(ii) **CA**. [2]

$W = \frac{1}{2}ab = \frac{1}{2}(175\times10^{3} - 95\times10^{3})(0.44 - 0.79)$

$= -14000$ J

(c) For **each** of the processes **AB**, **BC**, **CA** and the whole cycle **ABCA**, write the values of W (the work done by the gas), ΔU (the change in internal energy of the gas) and Q (the heat supplied to the gas). The numbers in bold have been added to save time with repeated calculations. [4]

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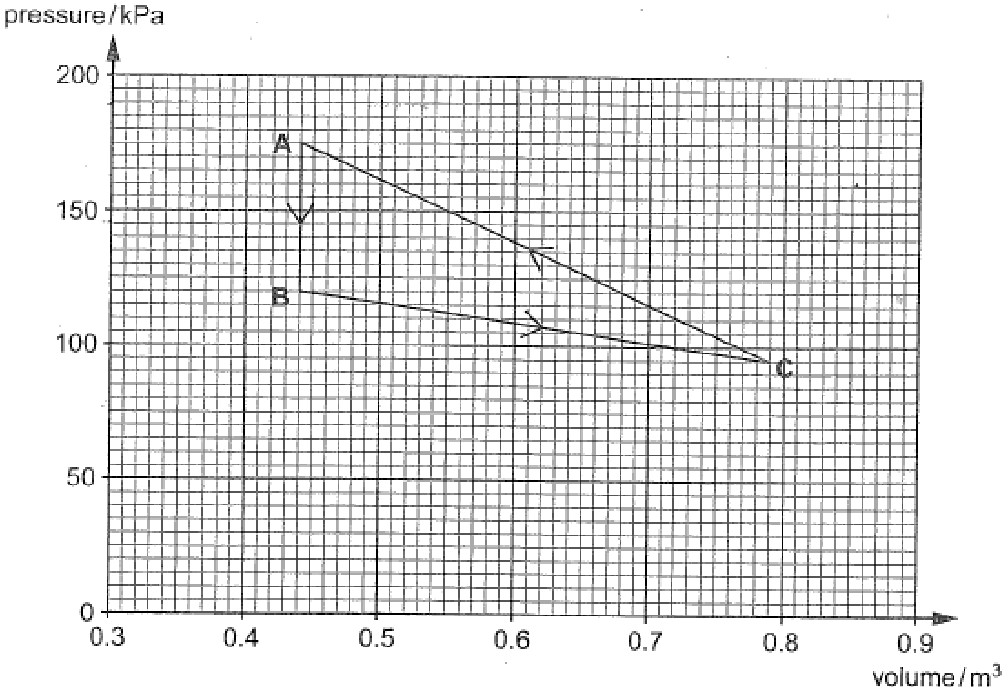

(a) There are **28.9 mol** of gas. The temperatures of points **A** and **B** are 321 K and 220 K respectively.

(i) Show that the temperature of **C** is 313 K. [2]

$pV = nRT$ $\cancel{n = \frac{pV}{RT}}$ $T = \frac{pV}{nR}$ $\cancel{\frac{175 \times 10^3 \times 0.9}{28.9 \times 8.31}}$

$\frac{95 \times 10^3 \times 0.79}{28.9 \times 8.31} =$ ~~313K~~ 313K

(ii) Calculate the change in internal energy, ΔU, for **AB**. [2]

$U = \frac{3}{2} nRT$ $\frac{3}{2}\ 28.9 \times 8.31 \times 321$ 115.6×10^3

$\frac{3}{2} \times 28.9 \times 8.31 \times 220 = 79.3 \times 10^3$

$115.6 \times 10^3 - 79.3 \times 10^3 = 36300\ J$

(b) Determine the work done **by** the gas, W, for:

(i) **AB**; [1]

0 J

(ii) **CA**. [2]

$W = p\Delta V$

$95 \times 10^3 \times 0.35 = 33250$

$25 \times 10^3 \times 0.35 = 875$

-42000 J done by gas

(c) For **each** of the processes **AB**, **BC**, **CA** and the whole cycle **ABCA**, write the values of W (the work done by the gas), ΔU (the change in internal energy of the gas) and Q (the heat supplied to the gas). The numbers in bold have been added to save time with repeated calculations. [4]

	Process			
	AB	**BC**	**CA**	**ABCA**
W	0 kJ	**37.6 kJ**	-42 kJ	-4.4 kJ
ΔU	-36.4	**33.5 kJ**	**2.9 kJ**	0
Q	-36.4	71.1 kJ	-39.1 kJ	-4.4 kJ

71.1 -39.1

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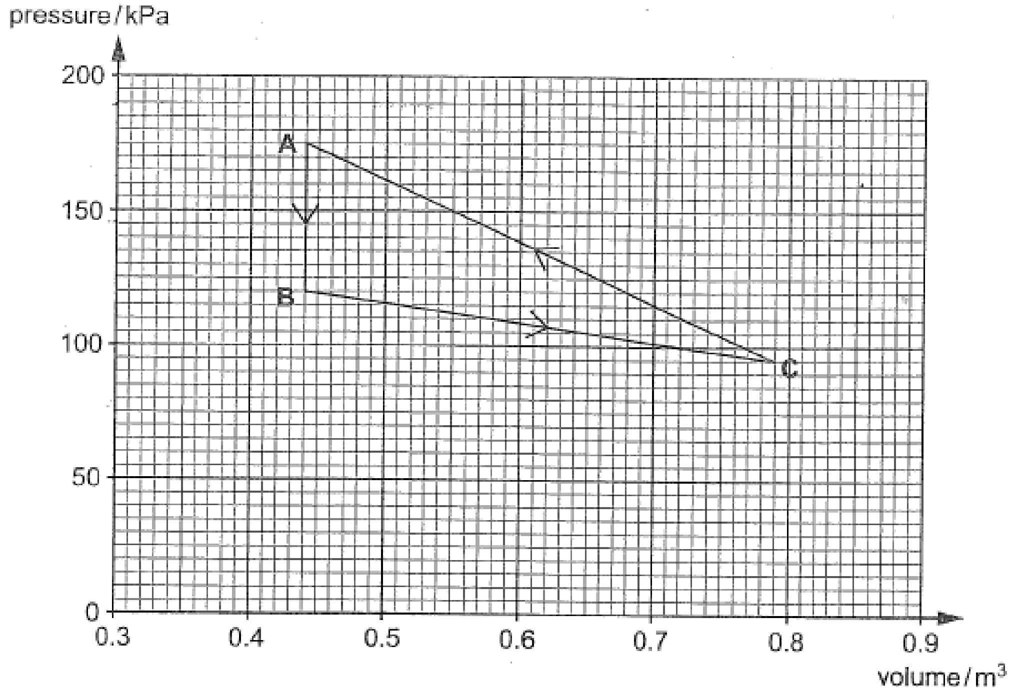

(a) There are **28.9 mol** of gas. The temperatures of points **A** and **B** are 321 K and 220 K respectively.

(i) Show that the temperature of **C** is 313 K. [2]

$pV = nRT$ $\quad T = \frac{pV}{nR}$ $\quad \cancel{\frac{115 \times 10^3 \times 0.49}{28.9 \times 8.31}}$

$\frac{95 \times 10^3 \times 0.79}{28.9 \times 8.31} = 313K$

(ii) Calculate the change in internal energy, ΔU, for **AB**. [2]

$U = \frac{3}{2} nKT$ $\quad \frac{3}{2}\, 28.9 \times 8.31 \times 321$ $\quad 115.6 \times 10^3$

$\frac{3}{2} \times 28.9 \times 8.31 \times 220 = 79.3 \times 10^3$

$115.6 \times 10^3 - 79.3 \times 10^3 = 36300\,J$

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(i) **AB**; [1]

0 J

(ii) **CA**. [2]

$W = p\Delta V$

$95 \times 10^3 \times 0.35 = 33250$

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-42000 J done by gas

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	AB	BC	CA	ABCA
W	0 kJ	**37.6 kJ**	−42 kJ	−4.4 kJ
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Q	−36.4	71.1 kJ	−39.1 kJ	−4.4 kJ

71.1 −39.1