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THE UNIVERSITY OF NEW SOUTH WALES
SCHOOL OF PHYSICS

PHYS1169 PHYSICS 1A
(Chemical, Mechanical & Mining Engineering)

TEST 1
SESSION 1, 2002

Time Allowed: 1.5 hours

Family Name	Initials
Print	
Student ID	
Signature	

Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

INSTRUCTIONS

1. **Do not read or write on this paper until instructed to do so.**
2. For each test attempted, answer all questions.
3. Answer questions in the spaces provided.
4. Questions are not necessarily of equal value.
5. For each question, full working and explanation must be shown.
6. Answers must be written in ink. Pencil may only be used for drawings, sketching or graphs.
7. Portable, solar powered electronic calculators will be supplied.
8. **This booklet must be handed in at the end of the examination.**

DATA SHEET

1 atmosphere (Standard air pressure)	1.01×10^{5} Pa
Latent heat of vaporisation of water at constant pressure	22.56×10^{5} J kg^{-1}
Latent heat of fusion of ice, L_f	3.34×10^{5} J kg^{-1}
Avogadro's constant, N	6.022×10^{23} (g mol)$^{-1}$
Charge on electron, e	1.602×10^{-19} C (negative)
Gas constant, R	8.314 J K^{-1}(g mol)$^{-1}$
	0.0821 litre-atm K^{-1} (g mol)$^{-1}$
Molecular weight of hydrogen, M	2.00×10^{-3} kg(g mol)$^{-1}$
Atomic mass unit , u	1.661×10^{-27} kg = 931.5 MeV/c^2
Mass of electron, m_e	9.109×10^{-31} kg = 5.486×10^{-4} u
Mass of neutron, m_n	1.675×10^{-27} kg = 1.0087 u
Mass of proton, m_p	1.673×10^{-27} kg = 1.0073 u
Velocity of sound in air (20°C and 1 atm)	343 ms^{-1}
Boltzmann's constant, k_B	1.381×10^{-23} JK^{-1}
Permittivity of free space, ε_o	8.854×10^{-12} C^2 N^{-1} m^{-2}
Permeability of free space, μ_o	$4\pi\times10^{-7}$ NA^{-2}
Earth's gravitational acceleration, g	9.80 m s^{-2}
Speed of light, c	2.998×10^{8} m s^{-1}
Coulomb's constant, k	8.99×10^{9} Nm^2 C^{-2}
Universal gravitation constant, G	6.673×10^{-11}N m^2 kg^{-2}
Planck's constant, h	6.626×10^{-34}J s
Rydbergs' constant, R_H	1.097×10^{7} m^{-1}
Density of water, ρ	1.00×10^{3} kg m^{-3}
Mass of Earth	5.98×10^{24} kg
Average radius of Earth	6.37×10^{6} m
Mass of Moon	7.36×10^{22} kg
Average Earth-Moon distance	3.84×10^{8} m
Mass of Sun	1.99×10^{30} kg
Radius of Sun	6.96×10^{8} m
Average Earth-Sun distance	1.496×10^{11} m
Bohr radius, a_o	5.29×10^{-11} m
Hydrogen ground state, E_o	-13.606 eV
Volume of 1 g mole ideal gas at 101.3 kPa (1 atm) and at 0°C (273 K)	2.241×10^{-2}m^3
at 25°C (298 K)	2.447×10^{-2}m^3
Mechanical equivalent of heat, 1 cal	4.186 J
Stefan's Constant, σ	5.67×10^{-8} Js^{-1}m^{-2}K^{-4}
Wien's Constant, B	2.898×10^{-3} m.K.
1 eV	1.60×10^{-19} J
Threshold of hearing, I_o	1×10^{-12} W m^{-2}

QUESTION 1 **[Marks 8]**

Two vectors are given by

$$\mathbf{a} = 2\,\mathbf{i} - \mathbf{j}$$
$$\mathbf{b} = \mathbf{i} + 2\,\mathbf{j} + \mathbf{k}$$

(a) Calculate $\mathbf{a} + 3\,\mathbf{b}$

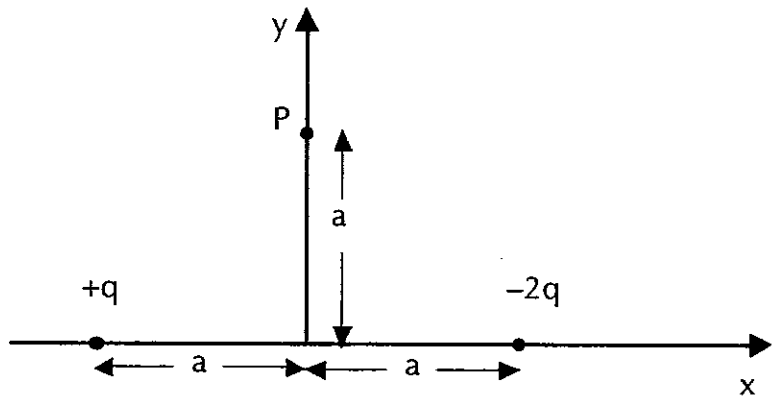
(b) Calculate $\mathbf{a} \cdot \mathbf{b}$

What do you deduce about the angle between **a** and **b**?

(c) Calculate $\mathbf{a} \times \mathbf{b}$

QUESTION 2 **[Marks 10]**

Two point charges, one of charge +q and the other of charge –2q, are situated on the x axis as shown.



(a) Derive an expression for vector components of the electric field intensity at P, in rectangular co-ordinates;

(b) Determine the direction of the electric field at P relative to the x axis;

(c) Find an expression for the electric potential at point P.

QUESTION 3 **[Marks 10]**

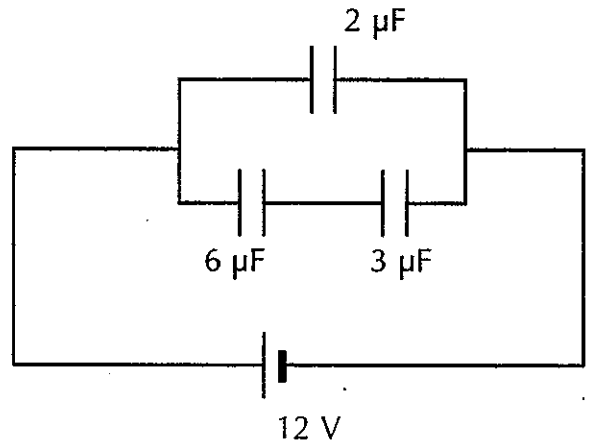
For the circuit shown, showing all your reasoning and working, determine:

(a) the total equivalent capacitance of this combination of capacitors

(b) the total charge drawn from the battery

(c) the charge on the 3 μF capacitor

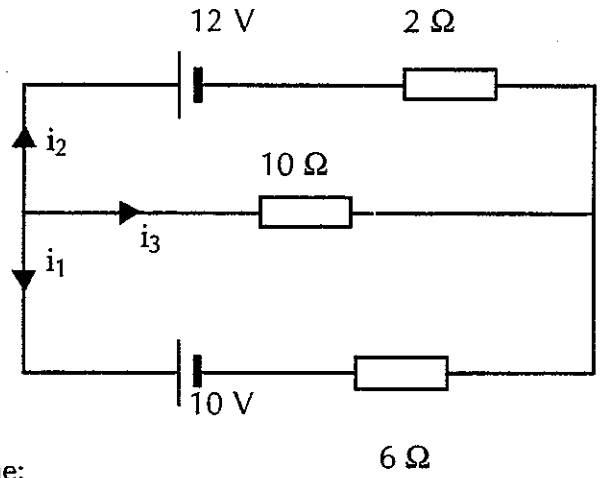
(d) the potential difference across the 3 μF capacitor



QUESTION 4 **[Marks 12]**

(a) State Kirchhoff's rules for direct current circuits.

(b) For the circuit shown, use Kirchhoff's rules to write down three equations from which the currents i_1, i_2 and i_3 could be determined,
DO NOT GO ON TO SOLVE THOSE EQUATIONS.



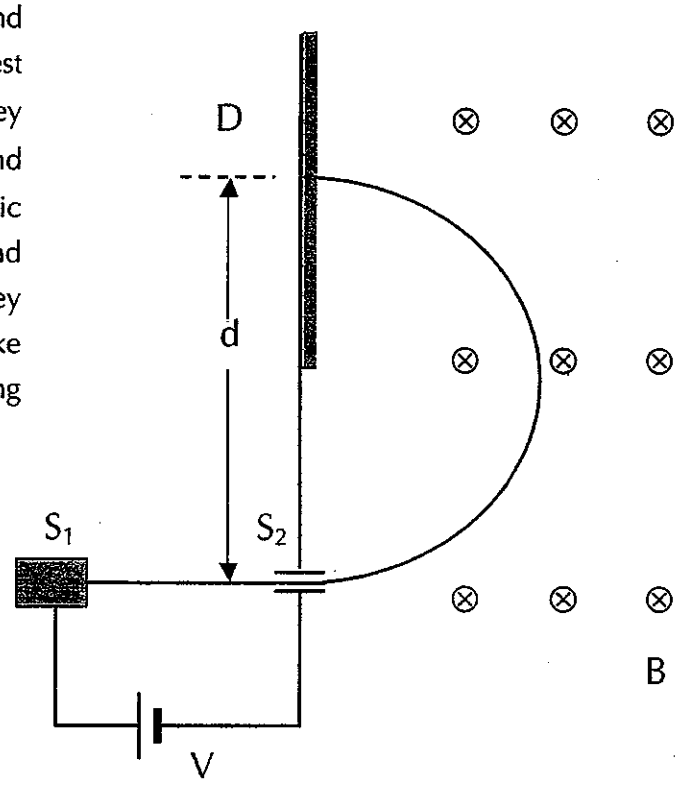
(c) Given the current i_2 has a value 1A, determine:
(i) the potential difference across the 2Ω resistor
(ii) the value of the current i_1

(d) Is power supplied by, or delivered to the 12 V battery? Give your reasoning.

QUESTION 5

[Marks 10]

The diagram shows a plan view of a mass spectrometer. In it ions of mass m and charge +q are accelerated to S_2 from rest at S_1 by a potential difference of V. They emerge through a small hole at S_2 and enter a uniform magnetic field, of magnetic induction B, directed at right angles and into the plane of the paper. In the field they follow a semicircular path until they strike the detector D. Showing all your reasoning and working, derive expressions for



(a) The kinetic energy gained by the ions from S_1 to S_2

(b) The velocity of the ions on entering S_2

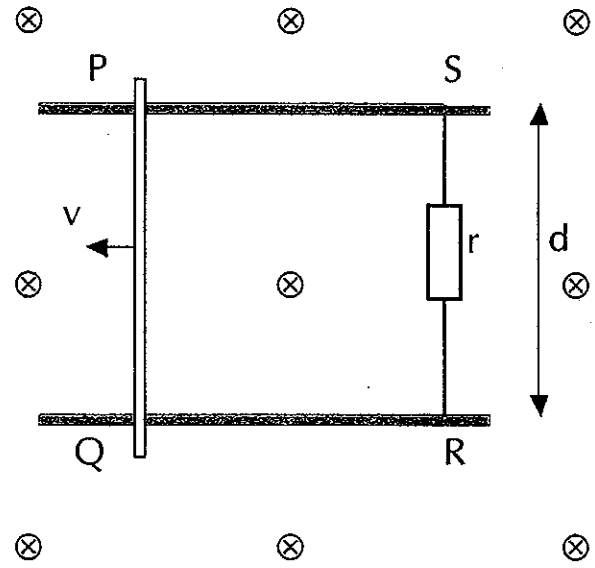
(c) The distance d from S_2 at which the ions strike the detector array.

QUESTION 6 **[Marks 10]**

(a) State Faraday's Law of electromagnetic induction, defining all the symbols used.

(b) The diagram shows a conducting rod PQ making contact with parallel metal rails PS and QR, which are a distance d apart. Both the rails and the rod have negligible resistance.

The rails are connected at S and R by a resistor of resistance r. A uniform magnetic induction B is directed vertically down into the plane of the paper. The rod moves to the left at speed v, as shown in the diagram.



(i) Showing all your reasoning and working, derive an expression for the magnitude of the current in the loop PQRS.

(ii) What is the direction of this current? Justify your answer.