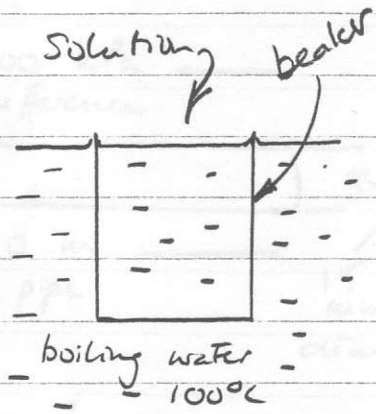
Transfer problems — {1}

A Physics

1. A chemist is heating a solution in a glass beaker. The beaker is a cylinder, 6 cm diameter, 8 cm deep, of glass 1.6 mm thick, thermal conductivity 0.8 W/m/K



(a) Draw a diagram to show how heat energy reaches the solution (1)

(b) Calculate the area of the glass beaker. (3)

(c) Calculate the volume of solution (2)

(d) Calculate the mass of solution, knowing that its density is 1.1 g/cm3 (2)

$\Pi = \partial V$!

(e) The chemist notes that the solution heats up from 20°C to 30°C in 20 sec. Calculate the specific heat capacity of the solution. (4) $\boxed{12}$

Electron drift

2 What is the electron drift velocity in the lead of a 13 A mains (240 V) kettle, with wires of 1 mm diameter copper? (4)

$e = -1.6 \times 10^{-19}$ C

$n_{Cu} = 10^{28}$ /m3

3 A 60 W mains (240 V) bulb has a tungsten filament 0.1 mm diameter

a) What is the electron drift velocity? (6) $n_{tungsten} = 10^{28}$/m3

b) Does it matter that the bulb runs on 50 Hz mains ac? (2)

4 An aluminium cable of 10 cm diameter delivers power from Ratcliffe power station to Nottingham. The electron drift velocity is 1 mm/sec $n_{Al} = 10^{27}$ /m3

a) What current is flowing? (4)

b) If the cable voltage is 400 kV, what power is being delivered? (4)

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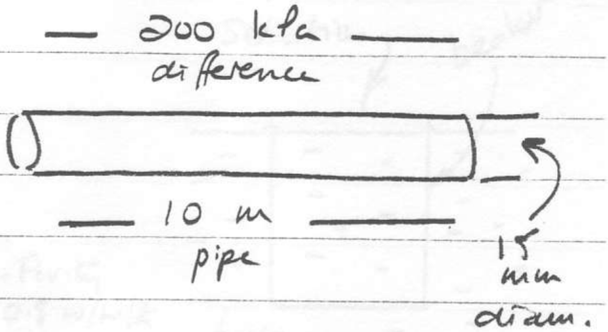
Transfer problems {2} A Physics

Liquid flow.

5. In the situation shown, what is the effect on water flow rate of each of the following...



a) increasing length to 20 m (2)

b) increasing pressure difference to 400,000 Pa (2)

c) increasing pipe diameter to 30 mm (2)

d) increasing pipe diameter to 22 mm. (2)

e) passing a liquid with viscosity 80% that of water (2)

6. A pipe of cross section area 4 cm^2 splits into two pipes each of area 1 cm^2.
Water flows into the junction at a speed of 10 cm/s

(a) Sketch the pipe layout (1)

(b) Calculate the volume of water flowing each second into the junction (2)

c) Calculate the water speed in each of the smaller pipes (2)

7. A 22 mm diameter water pipe splits into two 15 mm diameter pipes.
Each small pipe must deliver 50 cm^3/sec

a) Calculate the water speed in each pipe. (3)

b) What must the water speed be in the big pipe? (2).

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Trans for Problems — Answers 1+2 — A Physics

1\. a)  (1) (b) Area = 0 + $\pi r^2 + 2\pi r l$ (1) (1) $= 0.0179$ (1) m^2 (3)
(or $179\ cm^2$)

c) Volume $V = \pi r^2 l$ (1) $= 226\ cm^3$ (1) (or $226 \times 10^{-6}\ m^3$)

d) use $M = DV = 1.1 \times 226$ (1) $= 248.6$ (1) g (2)

(e) Heat energy passing through glass container walls in 20s = Heat energy to raise solution temp. 20 – 30°C (av. 25°C)

use $Q/t_{(J/s)} = \left(k A \dfrac{\Delta\theta}{\Delta x}\right)$ (1) $\times 20_{sec}$ (1) $= m\, c_{solution} \times \Delta\theta$ (1)

$0.8 \times 0.0179 \times \dfrac{(100-25) \times 20}{1.6 \times 10^{-3}} = 248.6 \times C \times 10.$

k_{glass} (must be in m!) — c in J/g/k — phew!

$671.25 \times 20 = 2486 \times C.$

So c solution is $671.25 / 2486 = 5.4$ (1) J/g/k

2\. $I = nAve$ — 1mm diam → $A = \pi r^2$ (1) $= 785 \times 10^{-9}$ (1) m^2

so drift velocity $v = I / nAe$ (1) $= 13 / 1\times10^{28} \times 785 \times 10^{-9} \times 1.6 \times 10^{-19} = 0.01\ m/s$ (1)
$= 1\ cm/s$ (4

3\. a) $P = IV \rightarrow I = P/V$ (1) $= 60/240 = 0.25\ A$ (1) Area $= \pi r^2$ (1) $= 7.85 \times 10^{-9}\ m^2$ (1)

$I = nAve \rightarrow v = I / nAe$ (1) $= 0.25 / 1\times10^{28} \times 7.85 \times 10^{-9} \times 1.6 \times 10^{-19} = 0.02\ m/s$ (1)
(= 2cm/s)

(b) ac – current constantly reversing... heating effect regardless of current direction (1) (6

4\. a) $I = nAve$ (1) $= 1\times10^{27} \times 7.85 \times 10^{-3} \times 1\times10^{-3} \times 1.6 \times 10^{-19}$ — $A = \pi r^2$ (1) $= 0.00785\ m^2$
$= 7.85 \times 10^{-3}\ m^2$ (1)

$= 1257$ (1) Amps

b) $P = IV$ (1) $= 1257 \times 400{,}\times10^3 = 5.03 \times 10^8\ W = 503$ (1) MW (6)

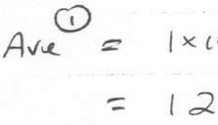
5\. Use... $\{m/t\}_{kg/s} = \dfrac{c \times A^2}{\text{viscosity } \eta} \times \dfrac{\Delta p}{l}$ — (a) $2 \times l \rightarrow \frac{1}{2}$ rate (1) $= 0.0025\ m^3/s$ (1)

(b) $2 \times \Delta P \rightarrow 2 \times$ rate (1) $= 0.01$ (1) m^3/s

c) 2 × diam → 4 × Area (1) → 16 × flow rate (1) $= 0.08\ m^3/s$

d) increase d × 22/15 → area $\times \left(\frac{22}{15}\right)^2 = 2.15$ (1) → flow rate $\times (2.15)^2 = \times 4.63$ (1) $= 0.023\ m^3/s$

e) 80% viscosity → $\frac{1}{0.8}$ (1) of flow rate $= \dfrac{0.005}{0.8} = 0.0063$ (1) m^3/s [10]

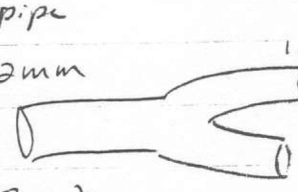
6\. a)  (1) (b) volume/sec $= V \times A$ (1) $= 10 \times 4 = 40$ (1) cm^3/s.

(c) $40\ cm^3/s$ in $= 40\ cm^3/s$ out (1) $= 2 \times V_{out} \times A_{out} = 2 \times V \times 1$

So $V_{out} = 20\ cm/s$ (1) in each small pipe [5]

7\. a) for small pipes... $A = \pi r^2 = 1.77\ cm^2$ (1)

so $VA = 50$ (1) $cm^3/s \rightarrow V = 50/1.77 = 28.3\ cm/sec$ (1)



b) $V_{big} A_{big} = 2 \times V_{small} \times A_{small}$ (1) $A_{big} = \pi r^2 = 3.8\ cm^2$

So $V_{big} = 2 \times 28.3 \times 1.77 / 3.8 = 26.4\ cm/s$ (1) (or $V_{big} \times A_{big} = 100\ cm^3/s$)

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