# Mark Scheme 2826/01
# January 2006

UNIFYING CONCEPTS
IN PHYSICS

1 **(a)** speed as distance per unit time and velocity as displacement per unit time {1}

velocity requires a direction to be given as well as a magnitude {1} [2]

OR definition of speed or velocity followed by

speed as a scalar quantity and velocity as a vector quantity

**(b)** elastic materials return to their original shape when a distorting force is removed {1}

plastic materials are have their shape permanently changed by a distorting force {1} [2]

Allow in terms of elastic/plastic collisions

**(c)** Heat is a form of energy which flows as a result of a temperature gradient {1}

Temperature is the property of a body which determines the direction of heat flow {1}

Allow Temperature (of an ideal gas) is proportional to the (mean) kinetic energy of the molecules

[2]

**(d)** fission is when splitting (into two parts releasing energy) takes place and

fusion is when joining together takes place {1}

nuclei as the active particles {1}

[2]

**(e)** kinetic energy is the energy a body possesses by virtue of its speed {1}

as an energy it is a measure of force x distance {1}

the rate of change of momentum defines force {1}

momentum is therefore a measure of force x time {1} [4]

Other possible answers will score a maximum of 3 unless the force x distance relationship is given for kinetic energy and the force x time relationship is given for momentum

momentum is always conserved in a collision (in the absence of external forces) {1}

but kinetic energy may be lost – with qualification of what happens {1}

kinetic energy is proportional to $v^2$ but momentum is proportional to $v$ {1}

kinetic energy is a scalar; momentum is a vector {1}

[Total : 12]

**2. (a) (i)**

| capacitor | capacitance / μF | charge / μC | p.d. / V | energy / μJ |
|---|---|---|---|---|
| X | 5 | 30 | $= Q/C$<br>= 6 (V) {1} | $=½ CV^2$ {1}<br>$= ½ \times 5 \times 6^2$<br>= 90 {1} |
| Y | 25 | $= CV$<br>$= 25 \times 6$<br>= 150 (μC) {1} | = 6 (V) {1} | = 450 {1} |
| Z | 10 | 30 + 150 =<br>180 (μC) {1} | $= Q/C$<br>= 180/10<br>= 18 (V) {1} | = 1620 {1} |

Each box correctly calculated scores [1] + [1] for $½ CV^2$ [9]

**(ii)** **1** 18 V + 6 V = 24 (V) {1}

**2** 180 (μC) {1}

**3** 180 / 24 = 7.5 {1}

**4** 90 + 450 + 1620 = 2160 (μJ) {1} [4]

**(b)(i)** Kirchhoff's second law OR conservation of energy {1}

**(ii)** Kirchhoff's first law OR conservation of charge {1} [2]

**(c)(i)** time constant = $CR$ {1}

$= 7.5 \times 10^{-6} \times 200\,000 = 1.5$ (s) {1} [2]

**(ii)** $Q = Q_o e^{\frac{-4CR}{CR}}$ {1}

$Q/Q_o = e^{-4} = 0.0183$ {1} [2]

[Total : 19]

3. **(a)** work got out / work put in {1} [1]
OR in terms of power OR as a percentage
OR percentage of useful output

**(b)** e.g insulation improved by increasing thickness of insulating material {1}
efficiency dependent so less heat is lost through the insulation {1}
so less fuel needs to be burnt to heat the house {1}
so less carbon dioxide is produced {1} [3]
MAXIMUM 3 points required only but must be in a sensible sequence

**(c)(i)** efficiency = 42 MW x *t* / 120 MW x *t* {1}
= 0.35 (= 35%) {1} [2]

**(ii)** maximum theoretical efficiency = (750 – 290)/ 750 {1}
= 460/750 = 0.613 (= 61.3%) {1} [2]

**(iii)** $T_H$ needs to be .....raised: $T_C$ needs to be .....lowered {1} [1]

**(iv)** **1** e.g. raising $T_H$ would increase the pressure in the turbine (so it might explode)
OR the materials in it might melt {1}

**2** e.g. lowering $T_C$ would be very difficult as it is the temperature of the cooling water (impossible to wait until winter) {1}
if done by refrigeration this would need power, (which would reduce overall efficiency) AND/ OR the cooling water might freeze {1} [3]

**(v)** 0 (zero) K {1} [1]

[Total : 13]

4 (a) zero (do not allow 'small') {1} [1]

(b) 300 W for 1 watt therefore 300 W x 20 for 20 W 6000 W {1} [1]

(c) e.g. if run at 92 K there is a danger that superconductivity will cease as a result of a slight temperature rise {1}
a 15 K difference provides a safety region {1}
77 K is the boiling point of liquid nitrogen {1}
other sensible suggestion {1}
MAXIMUM [2] [2]

(d) (i) area of cross-section of wire = $10^{-6}$ m$^2$ {1}
current = $10^{-6}$ m$^2$ x 2.0 x $10^8$ A m$^{-2}$ {1}
= 200 A {0} [2]

(ii) $B = \dfrac{1.26 \times 10^{-6} \times 200 \times 3200}{2 \times 0.30}$ {1}
= 1.34 T {1} [2]

(e) (i) $F = BQv$ {1} [1]

(ii) $BQv = m \times \dfrac{v^2}{r}$ {1}
$r = mv/BQ$ {1}
$m$ = 235 x 1.66 x $10^{-27}$ kg {1}
$r = \dfrac{235 \times 1.66 \times 10^{-27} \times 8.3 \times 10^5}{1.34 \times 1.6 \times 10^{-19}} = 1.51$ m {1} [4]

(iii)
circular paths for both ions {1}
U-235 ion with slightly smaller radius {1}
paths curving upwards {1} [3]

[Total : 16]