# ADVANCING PHYSICS ' CLOCKWORK UNIVERSE' MARK SCHEME
# JUNE 2001 CODE 2863 (7733)

1) (a) sample A has more nuclei P by a factor of eight P .
(b) $1/2^4 \times 1600$ P = 100 counts per second P . [4]

2) (a) $1.0 \times 10^5 \times 2.0 = 0.5 \times p$ P $p = 4.0 \times 10^5$ Pa.
(b) constant temperature. P (or other sensible) [3]

3) (a) Large range of values – difficulty to fit on paper if linear P .
(b) ratio = $10^{-2}/10^3$ P = $10^{-5}$ P . [3]

4) Recall of $F = mv^2/r$ P $F = 25 \times 1.9^2/1.2$ P = 75 N P . [3]

5) (a) $-2 \times 10^6$ J $kg^{-1}$ P . [1]
(b) Point X is where field strengths 'cancel' OWTTE P .Moon is less massive so for equal field strength point X needs to be further from Earth.P [2]

6) (a) $c = (3\,pV/Nm)^{1/2} = (3 \times 1.5 \times 10^{-10} \times 2.5 \times 10^{-3}/ 1 \times 10^8 \times 6 \times 10^{-27})^{1/2}$ P.
= 1286 m $s^{-1}$ P . ( $1.0 \times 10^3$ m $s^{-1}$) [2]
(b) It would increase P by a factor of $2^{1/2}$ P. [2]

**Section A total = 20 marks**

7) (a)(i) 1.5 – 1.6 Hz P .
(a) (ii) approx same frequency P smaller amplitude P broader peak P [4]

(b) (i) when nat. frq. of molecule matches frq. of IR radiation resonance occurs P energy from IR transferred to vibrational energy of molecule.P (response in terms of photon and energy levels acceptable)
b(ii) $T = 2\pi (m/k)^{1/2} = 2\pi (1.7 \times 10^{-27}/510)^{1/2}$ P = $1.1(5) \times 10^{-14}$ s P
$f = 8.7 \times 10^{13}$ Hz . [5]

**Question total = 9 marks**

8) (a) (i) number of molecules in 1kg = $(1000 \times 6.02 \times 10^{23})/ 46.0$ P = $1.31 \times 10^{25}$ P .
average energy per molecule = $8.4 \times 10^5/ 1.31 \times 10^{25} = 6.42 \times 10^{-20}$ P .
(ii) energy = kT (approx) = $1.38 \times 10^{-23} \times 310$ P = $4.3 \times 10^{-21}$ J P.
(iii) $e^{(-E/kT)} = e^{(-6.4 \times 10^{\wedge}-20 / 4.3 \times 10^{\wedge}-21)}$ P = $3 \times 10^{-7}$ P . [7]

(b) Boltzmann factor proportional to rate of evaporation P. Rate of evaporation greater for ethanol than for water P . Rate of energy loss from body greater (accept 'cools it quicker' for last point.) P . [3]

**Question total = 10 marks**

9) (a) using square counting: each 1 $cm^2$ square has value 0.13 Ns P approximately 15 squares P so change of momentum = 1.9 kg $ms^{-1}$ P. (Can be done by triangles: correct use of trianglesP m P e P .) If simple multiplication only, 1 mark. [3]

(b) impulse = change of momentum.
1.9 = 0.045 v P v = 1.9/0.045P = 42 $ms^{-1}$ P (ecf) [3]
(c) larger change of momentum P increased initial velocity Pincreased range□P (or sensible physics alternative) [3]

**Question total = 9 marks**

10) (a) (i) $a = -gs/l = -9.8 \times 0.050/3.0 = -0.16\ ms^{-2}$ P .
(ii) $s = v_{av}t = \frac{1}{2} at^2$ P = $\frac{1}{2} \times 0.16 \times 0.2^2 = 3.2 \times 10^{-3}$ mP .
(iii) $0.050 - 3.2 \times 10^{-3} = 0.047$m P . [4]

(b) period = 4 x 0.84 = 3.36 s P.(3.34 s) [1]

(c)(i) acceleration always too largeP .
(ii) smaller time increments P so error in assuming uniform deceleration is minimisedP . [3]

**Question total = 8 marks**

11) (a) (i) RC = 530 x 470 x $10^{-6}$ P = 0.25 s.
(ii) $\Omega$. F = V $A^{-1}$ . $CV^{-1}$P = $C^{-1}$s. CP = s [3]

(b) (i) 20.0 x 0.37 P = 7.4 V
(ii) 2.7 V, 1.0 V (both)P.
(iii) points PlineP .
(iv) from graph 0.13 s P . [5]

(c) change value R or C P direction of change P [2]

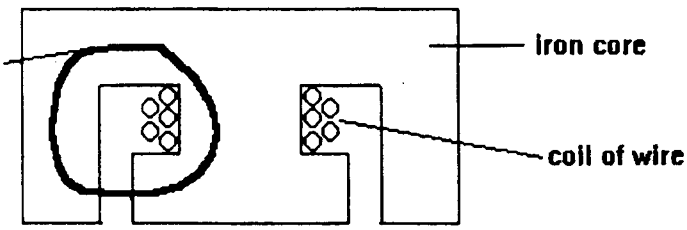
**Question total = 10 marks**

**Section B total = 46 + 4 QoC = 50 marks**

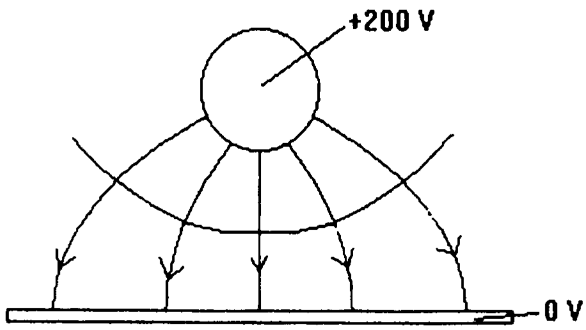
**Paper total 70 marks**

| | | | |
|---|---|---|---|
| 1. | (a) | 0 | 1 |
| | (b) | (+)2$e$ | 1 |
| | (c) | (+)2$e$/3<br>(accept correct calculated answer in coulombs) | 1 |
| | | | **3** |
| 2. | | $m = 2 \times 9.11 \times 10^{-31} = 1.82 \times 10^{-30}$ kg | 1 |
| | | ecf wrong mass:<br>$E = mc^2 = 1.82 \times 10^{-30} \times (3.00 \times 10^8)^2 = 1.6(4) \times 10^{-13}$ J<br>(so $8.2 \times 10^{-14}$ J worth [1]) | 1 |
| | | | **2** |
| 3. | | Bq | 1 |
| | | | **1** |

4.




| | | | |
|---|---|---|---|
| | | complete loop (accept right angle bends) | 1 |
| | | threading electric circuit | 1 |
| | | | **2** |
| 5. | (a) | five arrows pointing away from sphere | 1 |
| | (b) | about halfway along field lines,<br>at right angles to each (by eye) | 1<br>1 |




| | | | |
|---|---|---|---|
| | | | 3 |
| 6. | | $A = A_0 e^{-\lambda t}$ (not $N$ instead of $A$) | 1 |
| | | $= 7.5 \times 10^5 \times e^{-0.14} \times 20 = 4.56 \times 10^4$ Bq | 1 |
| | | (accept $t_{1/2} = \ln 2/\lambda = 4.98$ yr, $A = A_0/2^4 = 4.69 \times 10^4$ for 1 mark)<br>(accept alternative method using $A = \lambda N$ and $N = N_0 e^{-\lambda t}$ for 2 marks) | |
| | | | **2** |

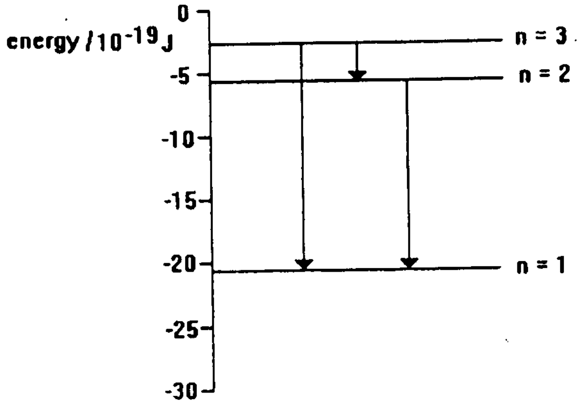
| | | | |
|---|---|---|---|
| 7. | (a) | 60 | 1 |
| | (b) | B | 1 |
| | | C | 1 |
| | | | **3** |
| 8. | | B | 1 |
| | | | **1** |
| 9. | (a) | C | 1 |
| | (b) | A | 1 |
| | | | **2** |
| 10. | (a) | any of the following, maximum [3]<br>• Current in primary coil generates a magnetic field / flux<br>• Which is changing / alternating<br>• Directed through secondary coil (by iron core)<br>• Resulting in a changing flux linkage in secondary coil<br>(resulting in an induced emf) | 3 |
| | (b) | sine curve with same period as current (by eye) | 1 |
| | | in phase (or $\pi$ out of phase) with current, any amplitude | 1 |
| | (c) | ecf incorrect flux curve | |
| | | sine curve (i.e. rate of change of flux curve) | 1 |
| | | $\pi/2$ out of phase wrt flux curve (ahead or behind) | 1 |
| | (d)(i) | $T = 1/f = 1/50 = 0.02$ s | 1 |
| | | EITHER | |
| | | peak emf $\approx$ peak flux linkage $\div$ $T/4$ | 1 |
| | | peak flux linkage = 400 x 0.005 = 2.0 Wb | 1 |
| | | OR<br>$V_0 = 2\pi f$ x peak flux linkage<br>Peak flux linkage = 400 $\div$ $100\pi$ = 1.27 Wb<br>(accept 8 Wb for 2 marks ecf) | |
| | (ii) | ecf 10 (d) (i): $n\phi = 2.0$ so $\phi = 2.0 \div 600 = 3.33 \times 10^{-3}$ Wb (= $BA$) | 1 |
| | | $A$ = ) $3.33 \times 10^{-3} \div 1.6 = 2.1 \times 10^{-3}$ m$^2$ | 1 |
| | | (8 Wb gives $8.4 \times 10^{-3}$ m$^2$, 1.27 Wb gives $1.4 \times 10^{-3}$ m$^2$) | |
| | | | **12** |
| 11. | (a) | ${}^{238}_{94}Pu \rightarrow {}^{234}_{92}U + {}^{4}_{2}He$<br>completely correct = [2]<br>incorrect but balanced [1] | 2 |
| | (b) | any of the following points, maximum [4]<br>• nucleus loses mass / binding energy (when it decays)<br>• resulting in kinetic energy<br>• carried away by alpha particle<br>• which ionises / collides with other plutonium atoms / nuclei (wtte)<br>• transferring (kinetic) energy at random to the metal (wwte) | 4 |

| | | |
|---|---|---|
| (c)(i) | energy per second = 100/0.15 = 667 W | 1 |
| | ecf: decay rate = $667/8.8\times10^{-13}$ | 1 |
| | (decay rate = $7.58\times10^{14}$ Bq, accept reverse argument) | |
| (ii) | $A = \lambda N$ | |
| | $\lambda = 0.69/T_{1/2} = 0.69 \div (86 \times 3600 \times 24 \times 365) = 2.54\times10^{-10}\ s^{-1}$ | 1 |
| | ecf incorrect value for decay constant: | |
| | $N = 1\times10^{15} \div 2.54\times10^{-10} = 3.92\times10^{24}$ | 1 |
| | ecf incorrect value of $N$: | |
| | $m = 238 \times 1.66\times10^{-27} \times 3.92\times10^{24} = 1.6$ kg | 1 |
| | | **11** |
| 12.(a)(i) | at least three parallel, equally spaced straight lines between plates | 1 |
| | arrows on lines pointing down (accept correct edge effects) | 1 |
| (ii) | parabolic path bending downwards (by eye) | 1 |
| (b)(i) | each proton subject to magnetic and electric forces | 1 |
| | which can be equal and opposite / balanced / cancel each other out | 1 |
| (ii) | $F = Bqv = qE$ | 1 |
| | cancellation of $q$ and manipulation of $v = E/B$ | 1 |
| (iii) | $E = 150 \times 10^3\ V\ m^{-1}$ | 1 |
| | ecf: $v = E/B = 150 \times 10^3/3 \times 10^{-2} = 5 \times 10^6\ m\ s^{-1}$ | 1 |
| (c) | any of the following, maximum [4] | 4 |

- the beam has two different velocities
- all of the particles in the beam have the same energy
- they are accelerated through same pd
- sample contains two different particles
- of different masses
- smaller peak has larger mass
- with one particle twice as massive as the other
- so sample contains deuterium (wtte) / helium

**13**

| | | |
|---|---|---|
| 13.(a) | (-)5.45 x $10^{-19}$ J and (-)2.42 x $10^{-19}$ J correctly calculated | 1 |
| | ecf: and placed on diagram correctly (by eye) | 1 |
| (b)(i) | [1] for each correct transition drawn<br>deduct [1] for arrows not pointing down | 3 |




| | | |
|---|---|---|
| (ii) | ecf incorrectly calculated energy levels: | |
| | photon energy = 5.45 x $10^{-19}$ – 2.42 x $10^{-19}$ = 3.03 x $10^{-19}$ J | 1 |
| | ecf incorrect photon energy: | |
| | $E = hf$ so $f = E/h$ = 3.02 x $10^{-19}$ ÷ 6.63 x $10^{-34}$ = 4.57 x $10^{14}$ Hz | 1 |
| | $c = f\lambda$ so $\lambda = c/f$ = 3.00 x $10^{8}$ ÷ 4.56 x $10^{14}$ = 6.56 x $10^{-7}$ m | 1 |
| | (accept 6.6 x $10^{-7}$ m) | |
| (c) | For an inelastic collision electron must raise atom from $n$ = 1 state to $n$ = 2 state (wtte) | 1 |
| | requiring an energy of at least 21.8 x $10^{-19}$ – 5.45 x $10^{-19}$ = 16.4 x $10^{-19}$ J | 1 |
| | which is 16.4 x $10^{-19}$ ÷ 1.6 x $10^{-19}$ = 10.2 eV (units conversion) | 1 |
| | | **11** |