Mark Scheme

Year 13 Physics

Mock Test

Time Allowed: 2 Hours

Total Marks: 100

15 April 2023

Calculator Allowed

1.

a		(The sum of) the <u>random</u> kinetic ; and potential energies of the atoms/molecules/particles of the gas	**1** **1**	**2**
		omitting atoms/molecules/particles scores zero marks		
b	**i**	n = pV/RT ; = $2.8 \times 10^5 \times 2.1 \times 10^{-3}/(8.3 \times 288)$; = 0.246 (mol)	**3**	
	ii	p/T = constant; T = (290/280) x 288 = ; 298 K = 25 °C	**3**	
		using pV = nRT with n = 0.25 mol gives 20 °C also possible ecf from b(i)		
	iii	ratio = $T_2/T_1 = p_2/p_1$ = 1.03 or 1.04 *or 1.02* ; internal energy α T	**2**	**8**

2.

(a)	(i)	Arrow (labelled F) directed towards centre of circle	B1	**Allow:** arrow drawn parallel to the string
	(ii)	Resultant force (F) acts at 90° to motion / velocity of bung so no work done is done by F (hence no change in speed)	B1 B1	**Allow:** No component of F acts in the direction of motion (B1) hence there is no acceleration <u>in the direction of motion</u> (AW) (B1)
(b)	(i)	Student <u>tries to</u> rotate bung at <u>constant</u> radius / <u>tries to</u> keep reference mark at end of tube (AW) Force F is calculated using $F = Mg$. where M is mass of slotted masses Measure time t for n revolutions of the bung (hence calculate T for 1 revolution). Measure radius r when <u>stationary</u> Calculate v using $2\pi r\, n/t$ (or $2\pi r/T$).	B1 B1 B1 B1 B1	**Not:** bald 'constant radius' **Not** : F = weight **Not:** 'take time for 1 revolution'
	(ii)	**1** Straight line of positive gradient <u>passing through the origin</u> **2** $F = \frac{m}{r} v^2$ hence gradient $= \frac{m}{r}$ Mass = <u>gradient</u> (of graph) x radius (of orbit)	B1 B1 B1	 Cannot award this mark if graph is curved Can score this mark if graph is curved

3.

(a)		Is in the opposite direction to the displacement Increases as the speed of the object decreases	B1 B1	If more than 2 ticks are given mark all and deduct 1 mark for each error
(b)	**(i)**	$f = \frac{1}{T} = \frac{1}{1.2}$ $f = 0.83 \quad (\text{Hz})$	B1	**Allow:** the fraction 5/6 only
	(ii)	$v_{max} = (2\pi f)\ A$ $0.08 = (2\pi \times 0.83)A$ $A = \frac{0.08}{(2\pi \times 0.83)} = 0.015 \quad (\text{m})$	C1 A1	Possible **ecf** from **(b)(i)** **Note:** Mark is for substitution; any subject Answer is 0.0153 (m) to 3 sf
	(iii)	$a_{max} = (2\pi f)^2 A$ $a_{max} = (2\pi \times 0.83)^2 \times 0.015$ $a_{max} = 0.42 \quad (\text{m s}^{-2})$	C1 A1	Possible **ecf** from **(b)(i)** and **(ii)** **Note:** Mark is for substitution **Ignore sign** Expect to see 0.41 if 2 sf values are used **Allow:** tangent used at $v = 0$ (M1) gradient of tangent calculated in range 0.37 to 0.44 (m s^{-2}) to 2sf (A1). Accept gradient of tangent =0.4 (m s^{-2})
(c)	**(i)**	Graph(s) tending to single peak with axes labelled in words or appropriate symbols Peak labelled as <u>natural / resonant</u> frequency (of system) or f_o • Resonance occurs when the <u>driving frequency</u> matches <u>natural / resonant</u> frequency (of system) • the <u>amplitude</u> of vibrations / energy (transferred) is then a <u>maximum</u> (AW)	B1 B1 B1 B1	Can be scored even if horizontal axis is not correctly labelled
	(ii)	A valid example of resonance Explanation to include • what does the driving and what is being driven • that this occurs at specific (driver) frequency	B1 B1	**Allow:** Mirror in car, Washing machine, Child on swing, microwave (oven), radio (tuning), Structures (in wind etc) MRI **Not** musical instruments

4.

(a)		coulomb <u>per</u> volt	B1	**Allow**: 1 F = 1 $\underline{CV^{-1}}$
(b)	**(i)**	<u>Electrons</u> flow 'clockwise' / negative to positive These are deposited on (plate) **A** (and hence becomes negatively charged) or These are removed from (plate) **B** (and hence become positively charged)	B1 B1	**Not**: **A** becomes negative / **B** becomes positive
	(ii)1	$Q = C \times V = 5.4 \times 10^{-9} \times 12$ charge = 6.48×10^{-8} (C)	B1	
	(ii)2	energy = $\frac{1}{2}V^2C = \frac{1}{2} \times 12^2 \times 5.4 \times 10^{-9}$ energy = 3.89×10^{-7} (J)	B1	Possible ecf if Q used from **(ii)1**
(c)	**(i)**	$R = \dfrac{12}{3.24 \times 10^{-6}}$ resistance = 3.7×10^6 (Ω)	M1 A0	**Allow**: 'R = 12/3.24μ' (= 3.7 MΩ)
	(ii)	time constant = CR = $5.4 \times 10^{-9} \times 3.7 \times 10^6$ or 0.02 (s) $I = I_0 e^{-t/CR} = 3.24 \times e^{-(0.080/0.020)}$ current = 0.059 (μA)	C1 A1	**Allow**: ecf for time constant **Allow**: 1 mark for 5.9×10^{-n}
(d)		(Total) resistance of circuit <u>halved</u> / time constant is <u>halved</u> Rate of discharge is <u>doubled</u> / (initial) current is <u>doubled</u>	B1 B1	

5.

(a)		Force is proportional to the product of the masses and inversely proportional to the square of their separation (AW)	B1	**Allow:** $F = \frac{GmM}{r^2}$ with **all** symbols defined.
(b)	**(i)**	$mg = \frac{GmM_J}{r^2}$	C1	**Allow:** formula with m cancelled
		$M_J \left(= \frac{g r^2}{G} \right) = \frac{7.5 \times (1.3 \times 10^8)^2}{6.67 \times 10^{-11}}$	C1	**Allow:** use of $T^2 = \frac{4\pi^2 r^3}{GM_J} \Rightarrow M_J = \frac{4\pi^2 (1.3 \times 10^8)^3}{6.67 \times 10^{-11} \times (7.2 \times 60^2)^2}$ **Note:** mark is for substitution with any subject
		M_J = 1.9 x 10^{27} (kg)	A1	
	(ii)	$\frac{g_M}{g_A} = \frac{r_A^2}{r_M^2}$		**Allow:** use of $g = \frac{GM_J}{r^2}$ with possible ecf for M_J from (b)(i)
		$\frac{g_M}{7.5} = \frac{(1.3 \times 10^8)^2}{(2.4 \times 10^{10})^2}$	C1	$g_M = \frac{(6.67 \times 10^{-11}) \times (1.9 \times 10^{27})}{(2.4 \times 10^{10})^2}$ **Note:** mark is for substitution
		g_M = 2.2 x 10^{-4} (N kg^{-1})	A1	g_M = 2.2 x 10^{-4} (N kg^{-1})
	(iii)	$T^2 \propto r^3$ OR T^2/r^3 = constant (= $4\pi^2/GM_J$)	C1	**Allow:** possible ecf for M_J from b(i) **Allow:** use of other correct formulae
		$\frac{T_M^2}{7.2^2} = \frac{(2.4 \times 10^{10})^3}{(1.3 \times 10^8)^3}$	C1	**Note:** mark is for substitution
		T_M = 1.8 x10^4 (hours)	A1	**Note** using times in seconds gives T_M = 6.49 x10^7 (s) scores 2 marks

6.

(a)	using $Q = mc\Delta\theta$ $= 3.00 \times 440 \times (84\text{-}27)$ ✓ 7.5×10^4 (J) ✓	**2**
(b)	using $Q = ml$ $= 1.20 \times 2.5 \times 10^4$ $= 3.0 \times 10^4$ (J) ✓	**1**
(c)	(heat supplied by lead changing state + heat supplied by cooling lead = heat gained by iron) 3.0×10^4 + heat supplied by cooling lead = 7.5×10^4 ✓ heat supplied by cooling lead = $4.5 \times 10^4 = mc\Delta\theta$ $c = 4.5 \times 10^4/(1.2 \times (327 - 84)$ ✓ $c = 154$ ($\text{J kg}^{-1}\text{K}^{-1}$) ✓	**3**
(d)	any **one** idea ✓ no allowance has been made for heat loss to the surroundings or the specific heats may not be a constant over the range of temperatures calculated	**1**

7.

(a)		Any **two** from: • Direction of the field (is incorrect) (AW) • The field lines should be curved / not straight (lines) • The field line(s) should be perpendicular at the plate(s) • The separation between the field lines cannot be the same / diagram shows a uniform field	B1×2	**Allow** answers on Fig. 2.1
(b)	**(i)**	gradient = 1.25 ($\times 10^{-7}$) (Q = gradient $\times 4\pi \times 8.85 \times 10^{-12}$) charge = 1.4×10^{-17} (C)	C1 A1	**Ignore** POT **Allow** gradient in the range 1.20 to 1.30 ($\times 10^{-7}$) **Allow** full credit for substitution method ECF from incorrect value of calculated gradient
(b)	**(ii)**	The gradient decreases Explanation: Q decreases / there are fewer protons	B1 B1	**Allow** E is smaller for the same r
(c)	**(i)**	(E =) $\dfrac{1.5(\times 10^3)}{2.10(\times 10^{-2})}$ or 7.14 ($\times 10^4$) (mass of droplet = $\frac{4}{3}\pi r^3 \times \rho$ =) 8.15×10^{-15} (kg) (electrical force = weight / $EQ = mg$) $7.14 \times 10^4 \times Q = 8.15 \times 10^{-15} \times 9.81$ (Any subject) <u>and</u> hence charge = $1.1(2) \times 10^{-18}$ (C)	C1 C1 A1	**Allow** other correct methods **Ignore** POT **Note** there is no ECF for incorrect E or mass values **Allow** 1 mark for a bald $1.1\underline{2} \times 10^{-18}$ (C); answer to 3 SF or more but a bald 1.1×10^{-18} C scores zero
(c)	**(ii)**	(number of electrons = $\dfrac{1.12 \times 10^{-18}}{1.6 \times 10^{-19}}$ =) 7 (An <u>integer</u>)	B1	**Note** there is no ECF from **(i)** since 1.1×10^{-18} C is given **Not** 6.88 or 6.9 when using 1.1×10^{-18} C, but allow either of the integers 7 or 6

8.

a	(i)	absorbs enough energy (from the incident) electron(by collision) OR incident electron loses energy (to orbital electron) ✓ exact energy/10.1((eV) needed to make the transition/move up to level 2✓	2	For second mark must imply exact energy
a	(ii)	(*use of* $E_2 – E_1$) = *hf* -3.41 - - 13.6 = 10.19✓ energy of photon = 10.19 × 1.6 × 10^{-19} = 1.63 × 10^{-18} (J) ✓ 6.63 × 10^{-34} x *f* = 1.63 × 10^{-18} *f* = 2.46 × 10^{15} (Hz)✓ *(accept 2.5 but not 2.4)*	3	CE from energy difference but not from energy conversion
a	(iii)	Ek = 1.7 × 10^{-18} - 1.63 × 10^{-18}✓ = 7.0 × 10^{-20} J✓	2	
a	(iv)	energy required is 12.09 eV/1.9 x 10^{-18} ✓ energy of incident electron is only 10.63 eV/energy of electron less than this (1.7 × 10^{-18} J)✓	2	State and explain must have consistent units i.e. eV or J
b	(i)	Electrons return to lower levels by different routes/cascade/not straight to ground state✓	1	
b	(ii)	3✓ n= 3 to n=1 or n=3 to n=2 and n=2 to n=1✓	2	no CE from first mark

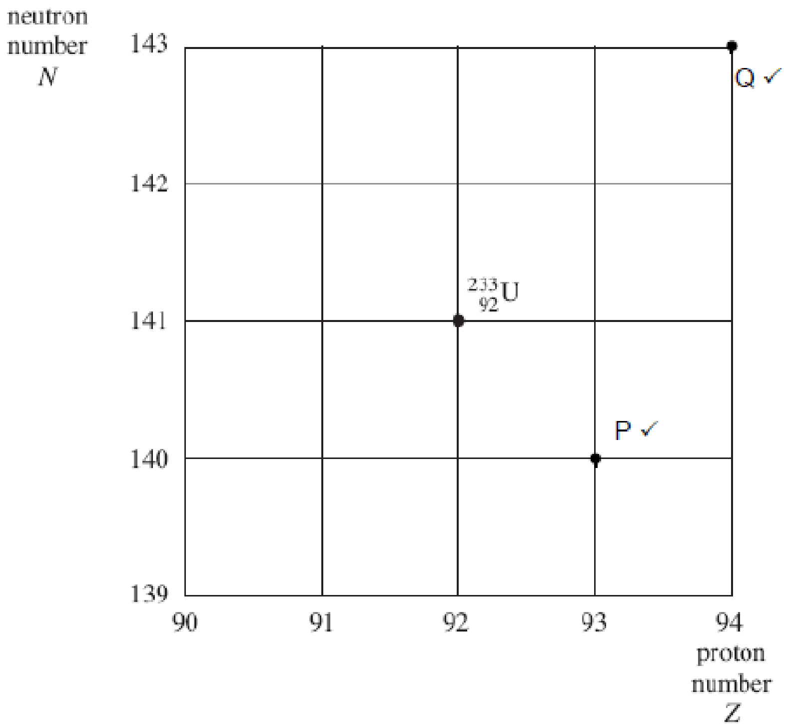
9.

(a)	The <u>induced</u> <u>e.m.f.</u> Is equal/proportional to the rate of change of (magnetic) flux (linkage) **Or** $\varepsilon = (-)\ d(N\Phi)/\Delta t$ with symbols defined	(1) (1)	**2**

(b)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) the idea that due to the magnet moving there is a changing field around the ring An e.m.f. induced (in a closed circuit hence a current flows) Change in direction of magnet, changes the direction of e.m.f./current Magnitude of e.m.f. (and current) depends on the rate of change of flux linkage **Or** magnitude of e.m.f. (and current) depends on position/ speed of magnet	 (1) (1) (1) (1)	**4**

(c)	Use of area $A = \pi r^2$ Use of $\varepsilon = BA/t$ Use of $I = V/R$ $I = 4.1$ A (accept 4.1 – 4.2 A depending on where rounding is done) (candidates who use a circumference instead of an area can only score MP3) <u>Example of calculation</u> Area of coil = $\pi \times (0.05 \text{ m})^2 = 7.9 \times 10^{-3} \text{ m}^2$ $\varepsilon = BA/t = 0.035 \text{ T s}^{-1} \times 7.9 \times 10^{-3} \text{ m}^2 = 2.8 \times 10^{-4} \text{ V}$ $I = \varepsilon/R = 2.8 \times 10^{-4} \text{ V} / 6.7 \times 10^{-5}\ \Omega$ $I = 4.1$ A	(1) (1) (1) (1)	**4**

10.

a		$^{233}_{91}Pa$ ✓ anti (electron) neutrino ✓	**2**
b			**2**
c	i	$x = 4$ ✓	**1**
c	ii	mass defect = [(232.98915 + 1.00867) – (90.90368 + 138.87810 + 4 × 1.00867)] u ✓ = 0.18136 u ✓ energy released (= 0.18136 × 931) = 169 (MeV) ✓	**3**