



Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE 2010

MARKING SCHEME

PHYSICS

HIGHER LEVEL

General Guidelines

In considering this marking scheme the following points should be noted.

1. In many instances only key words are given – words that must appear in the correct context in the candidate's answer in order to merit the assigned marks.
2. Words, expressions or statements separated by a solidus, /, are alternatives which are equally acceptable. Words which are separated by a solidus and which are underlined, must appear in the correct context by including the rest of the statement to merit the assigned mark.
3. Answers that are separated by a double solidus, //, are answers which are mutually exclusive. A partial answer; from one side of the // may not be taken in conjunction with a partial answer; from the other side.
4. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.
5. The detail required in any answer is determined by the context and manner in which the question is asked and also by the number of marks assigned to the answer in the examination paper. Therefore, in any instance, it may vary from year to year.
6. For omission of appropriate units, or incorrect units, one mark is deducted, when indicated
7. Each time an arithmetical slip occurs in a calculation, one mark is deducted.

SECTION A (120 marks)

Each question carries 40 marks.

Question 1

In an experiment to investigate the relationship between the acceleration of a body and the force applied to it, a student recorded the following data.

F/N	0.20	0.40	0.60	0.80	1.00	1.20	1.40
$a/m\ s^{-2}$	0.08	0.18	0.28	0.31	0.45	0.51	0.60

Describe the steps involved in measuring the acceleration of the body.

- measure/calculate the initial velocity/speed 3
- measure/calculate the velocity/speed again (t seconds later) 3
- measure time interval from initial to final velocities / distance between light gates 3
- use relevant formula e.g. $v=u+at$ / $v^2=u^2+2as$ 3

12

Datalogging method:

- align motion sensor with body (e.g. trolley) / diagram (3)
- select START and release body (3)
- (select STOP and) display GRAPH of 'a vs. t' // 'v vs. t' (3)
- (use tool bar to) find average value for a // use slope (tool) to find $a (= \frac{dv}{dt})$ (3)

12

Using the recorded data, plot a graph to show the relationship between the acceleration the body and the force applied to it. What does your graph tell you about this relationship?

- label axes correctly on graph paper 3
- plot six points correctly 3
- (-1 per each incorrect/omitted point)
- straight line 3
- good distribution 3
- correct statement / correct equation / $a \propto F$ 4

16

Using your graph, find the mass of the body.

- correct method for slope 3
- (m =) 2.32 kg [range: 2.1 ↔ 2.4 kg] 3
- (-1 for omission of or incorrect units)

6

On a trial run of this experiment, a student found that the graph did not go through the origin. Suggest a reason for this and describe how the apparatus should be adjusted, so that the graph would go through the origin.

- friction / any valid reason 3
- elevate/adjust the track/slope 3

6

Question 2

In an experiment to measure the specific latent heat of vaporisation of water, a student used a copper calorimeter containing water and a sensitive thermometer. The water was cooled below room temperature before adding dry steam to it. The following measurements were recorded.

Mass of copper calorimeter	=	34.6 g
Initial mass of calorimeter and water	=	96.4 g
Mass of dry steam added	=	1.2 g
Initial temperature of calorimeter and cooled water	=	8.2 °C
Final temperature of calorimeter and water	=	20.0 °C

How was the water cooled below room temperature?

reference to appropriate use of ice / water taken from fridge 6
 (– 3 for inappropriate use of ice)

How was the steam dried?

use of steam trap / delivery tube sloped upwards 6

Describe how the mass of the steam was determined.

final mass of calorimeter plus contents/water – initial mass of calorimeter and contents/water 6

Why was a sensitive thermometer used?

for greater accuracy / to reduce(%) error / more significant figures / e.g. to read to 0.1 °C 6

24

Using the data, calculate the specific latent heat of vaporisation of water.

[heat lost by steam = heat gained by water and calorimeter]

$[m_s = 1.2 \times 10^{-3} \text{ (kg) and } m_w = 6.18 \times 10^{-2} \text{ (kg)}]$ h/m 3

$\Delta\theta_{sv} = 80 \text{ (K) and } \Delta\theta_w (= \Delta\theta_{cu}) = 11.8 \text{ (K)}$ 3

$(ml)_s + (mc\Delta\theta)_{s/v} = (mc\Delta\theta)_w + (mc\Delta\theta)_{cu}$ 4

(zero marks if ml component missing: otherwise, for omission of or incorrect quantity, –1 per quantity)

$(1.2 \times 10^{-3})l_v + (1.2 \times 10^{-3})(4180)(80) = (6.18 \times 10^{-2})(4180)(11.8) + (3.46 \times 10^{-2})(11.8)(390)$
 $/ (1.2 \times 10^{-3})l_v + 401.3 = 3048.2 + 159.2$ (–1 per each incorrect substitution) 3

$l_v = 2.34 \times 10^6 \text{ J kg}^{-1}$ (–1 for omission of or incorrect units) 3

16

Question 3

In an experiment to verify Snell's law, a student recorded the following data.

$i/^\circ$	30	40	50	55	60	65	70
$r/^\circ$	19	26	30	33	36	38	40

$\sin i$	0.500	0.643	0.766	0.819	0.866	0.906	0.939
$\sin r$	0.325	0.438	0.500	0.544	0.588	0.615	0.643

Draw a labelled diagram of the apparatus used. On your diagram, indicate an angle i and its corresponding angle r .

diagram to show:

- a target medium e.g. glass block 3
- incident ray (from ray box) 3
- perpendicular / normal and refracted ray 3
- label angles i and r 3

12

Using the recorded data, draw a suitable graph and explain how your graph verifies Snell's law.

- correct $\sin i$ and $\sin r$ values for six points (-1 per each incorrect/omitted point) 4
- label axes correctly on graph paper 3
- plot six points correctly (-1 per each incorrect/omitted point) 3
- straight line showing good distribution 3
- correct statement / correct equation / $\sin i \propto \sin r$ 3

Using your graph, find the refractive index

- correct slope method 3
- $(n =) 1.41$ [range: 1.38 – 1.52] 3

22

The student did not record any values of i below 30° , give two reasons why?

- to reduce the (percentage) error 3
- elaboration e.g. difficult to measure / read angles, $r < i$, etc. 3

6

Question 4

In an experiment to investigate the variation of the resistance R of a thermistor with its temperature θ , a student measured its resistance at different temperatures.

The table shows the measurements recorded.

$\theta/^\circ\text{C}$	20	30	40	50	60	70	80
R/Ω	2000	1300	800	400	200	90	40

Draw a labelled diagram of the apparatus used.

thermistor /resistance in liquid

thermometer (in waterbath/oil)

thermistor connected to **labelled** ohmmeter/(digital) multimeter/DMM

3

3

3

9

How was the resistance measured?

Th3 connected to meter

ohmmeter indicated (state/imply)

3

3

6

Describe how the temperature was varied.

heat source/hotplate/bunsen burner

6

6

Using the recorded data, plot a graph to show the variation of the resistance of a thermistor with its temperature.

label axes correctly on graph paper

plot six points correctly

smooth curve

good distribution

(-1 per each incorrect/omitted point)

3

3

3

3

Use your graph to estimate the average variation of resistance per kelvin in the range $45^\circ\text{C} - 55^\circ\text{C}$.

(\pm) $30 \Omega (^{\circ}\text{C}^{-1})$ or $\Omega (\text{K}^{-1})$ [range: $28 \leftrightarrow 32$]

(-1 for omission of or incorrect units)

3

15

In this investigation, why is the thermistor usually immersed in oil rather than in water?

oil is a better conductor of heat / water contains air / (impure) water conducts electricity

/good thermal contact

4

4

SECTION B (280 marks)

Question 5 Answer any eight of the following parts (a), (b), (c), etc.

- (a) **What are the two conditions for the equilibrium of a set of co-planar forces?**
 forces up = forces down // (algebraic) sum of forces acting is zero 4
 (algebraic) sum of the moments (of the forces about any point) is zero 3
- (b) **What is the critical angle of a sample of glass whose refractive index is 1.46?**
 $n = \frac{1}{\sin i_c}$ (4)
 $i_c = 43.2^\circ$ 7
- (c) **Name the parts labelled A and B of the spectrometer shown in the diagram.**
 A = (turn)table, B = telescope 4 + 3
- (d) **Explain why snow is slow to melt as the day-time temperatures rises above 0 °C .**
 latent heat (of snow/ice) / energy needed for change of state 4
 is (very) large 3
 (3 marks for relevant partial answer)
- (e) **What is the positive charge stored on a 5 μF capacitor when connected to 120 V d.c. supply?**
 $q = C V$ (4)
 $q = 6.0 \times 10^{-4} \text{ C} / 0.60 \text{ mC} / 600 \mu\text{C}$ (–1 for omission of or incorrect units) 7
- (f) **Which of the following devices is adjusted when tuning into a radio station?**
transformer, diode, capacitor. rheostat
 (tuning) capacitor 7
- (g) **State Faraday’s law of electromagnetic induction.**
 (induced) emf \propto // $e \propto \frac{d\phi}{dt}$ 4
 rate of change of (magnetic)flux // correct notation 3
- (h) **The peak voltage of an a.c. supply is 300 V. Calculate its rms voltage.**
 $\frac{300}{\sqrt{2}}$ / 212(V) 7
- (i) **Name the naturally occurring radioactive gas which seeps into buildings from underground rocks and which can cause lung cancer.**
 radon (gas) 7
- (j) **Give two advantages of a circular accelerator over a linear accelerator.**
 smaller (less space) // greater speeds/energy // etc. any two 4 + 3

or

State the principle of a moving-coil galvanometer.

- a current carrying conductor experiences a force 4
 (when placed) in a magnetic field. 3

Question 6

State Newton’s law of universal gravitation.

force proportional to product of masses $// F = \frac{Gm_1m_2}{d^2} / F \propto \frac{m_1m_2}{d^2}$ 3

(F) inversely/indirectly proportional to square of the distance // correct notation 3

Use this law to calculate the acceleration due to gravity at a height above the surface of the earth, which is twice the radius of the earth.

2d above surface results in a distance = 3d from earth’s centre (state/imply) 3

[for mass m on earth’s surface:] $mg = \frac{GMm}{d^2} / g = \frac{GM}{d^2} / g \propto \frac{1}{d^2}$ 3

[for a distance of 3d from centre of earth] $mg_1 = \frac{GMm}{(3d)^2} / g_1 = \frac{GM}{9d^2} / g_1 \propto \frac{1}{(3d)^2}$ 3

[for mass m on at distance (3d) from earth’s centre] $\therefore g_1 = \frac{g}{9} / 1.09 \text{ ms}^{-2}$ 3

(–1 for omission of or incorrect units) 18

A spacecraft carrying astronauts is on a straight line flight from the earth to the moon and after a while its engines are turned off.

(i) **Explain why the spacecraft continues on its journey to the moon, even though the engines are turned off.**
reference to Newton’s 1st law of motion / ‘because of its momentum/inertia’ 6

(ii) **Describe the variation in the weight of the astronauts as they travel to the moon.**
weight decreases (to zero) as the astronaut moves away from the earth 3

gains (a lesser than normal) weight as she/he approaches the moon 3
12

(iii) **At what height above the earth’s surface will the astronauts experience weightlessness?**
gravitational pull of earth = gravitational pull of moon 3

$$\frac{GM_E m}{R_1^2} = \frac{GM_m m}{R_2^2} \quad 3$$

$$\frac{M_E}{M_m} (=81) = \frac{R_1^2}{R_2^2} \quad 3$$

$$9 = \frac{R_1}{R_2} \quad (-1 \text{ for incomplete answer}) / \text{height above earth} = 3.39 \times 10^8 \text{ m} \quad 3$$

(–1 for omission of or incorrect units) 12

(iv) **The moon orbits the earth every 27.3 days. What is its velocity, expressed in metres per second?**

formula: (for one orbit:) $v = \frac{2\pi r}{T}$ 3

substitution: $v = \frac{2\pi(3.84 \times 10^8)}{27.3 \times 24 \times 60 \times 60}$ 3

answer: $v = 1022.9 \text{ m s}^{-1} (\approx 1.02 \times 10^3 \text{ m s}^{-1})$ 3

(–1 for omission of or incorrect units) 9

(v) **Why is there no atmosphere on the moon?**
gravitational force too weak (to sustain atmosphere) 5

5

Question 7

What is the Doppler effect?

- (apparent) change in frequency 3
due to (relative) motion between source and observer 3

Explain, with the aid of labelled diagrams, how this phenomenon occurs.

Diagram:

- labelled moving source of waves (-1 if no label) 3
shorter wavelength approaching observer 3
longer wavelength receding 3
correct reference to frequency change 3

(-1 if waves not clearly indicated /implied)

18

Describe a laboratory experiment to demonstrate the Doppler effect.

- source of sound (e.g buzzer) 3
swing source attached to string 3
note frequency change instant source passes observer 3
(source may also be propelled longitudinally along a string, etc.) 9

What causes the red shift in the spectrum of a distant star?

- stars move relative to earth 3
(longer λ if) star receding (from earth) 3

6

The yellow line emitted by a helium discharge tube in the laboratory has a wavelength of 587 nm as shown in the diagram. The same yellow line in the helium spectrum of a star has a measured wavelength of 590 nm.

What can you deduce about the motion of the star?

- star is receding/moving away from earth 3

Calculate the speed of the moving star.

$$\lambda' = \lambda \left(\frac{c+u}{c} \right) \quad // \quad f' = f \left(\frac{c}{c+u} \right) \quad 6$$

$$u = c \left(\frac{\lambda'}{\lambda} - 1 \right) \quad // \quad u = c \left(\frac{f}{f'} - 1 \right) \quad 3$$

substituti on [$f = 5.11073 \times 10^{14}$ and $f' = 5.08475 \times 10^{14}$] 3

$$u = 1.5333 \times 10^6 \text{ m s}^{-1} \quad 3$$

(-1 for omission of or incorrect units)

18

Give another application of the Doppler effect.

- radar, medical imaging, blood flow measurement (echocardiogram), temperature measurement, (underwater) acoustics, etc. 5

5

Question 8

A hair dryer with a plastic casing uses a coiled wire as a heat source. When an electric current flows through the coiled wire, the air around it heats up and a motorised fan blows the hot air out.

What is an electric current?

a flow of charge / e^- 6

Heating is one effect of an electric current. Give two other effects of an electric current.

magnetic 3

chemical 3

12

The diagram shows a basic electrical circuit for a hair dryer.

(i) Describe what happens:

(a) when switch A is closed and the rheostat is adjusted
fan operates and its speed (of rotation) changes 3

(b) when switch A and switch B are closed.
charge/current flows through coil // coil gets hot 3
fan blows hot air 3

9

(ii) The maximum power generated in the heating coil is 2 kW.

(a) What is the initial resistance of the coil?

(b) Calculate the current that flows through the coil when the dryer is turned on.

$P = IV$ 3

$I \left(= \frac{P}{V} \right) = \frac{2000}{230} / 8.7 \text{ A}$ 3
(-1 for omission of or incorrect units)

$V = RI / R = \frac{230}{8.696} / = 26.4 \Omega$ 3
(-1 for omission of or incorrect units)

9

(iii) A length of nichrome wire of diameter 0.17 mm is used for the coil.

Calculate the length of the coil of wire.

$A = \pi r^2$ 3

$A = (3.14)(0.085 \times 10^{-3})^2$ 3

$A = 2.27 \times 10^{-8} (\text{m}^2)$ 3

$\rho = \frac{RA}{l}$ 3

$l = \frac{(26.4)(2.27 \times 10^{-8})}{1.1 \times 10^{-6}}$ 3

$l = 0.5448 \text{ m} / 54.5 \text{ cm}$ 3
(-1 for omission of or incorrect units)

18

(iv) Explain why the current through the coil would decrease if the fan developed a fault and stopped working.

coil gets hot 4

its R increases 4

(any correct statement explaining why R_{cct} or R_{coil} has increased.... 2×4) 8

8

Question 9

What is thermionic emission?

the emission of electrons
(from the) surface of a hot metal

3
3

6

X-rays are produced when high-energy electrons collide with a target.

Draw a labelled diagram of an X-ray tube.

vacuum
cathode
target / anode
high (accelerating anode) voltage or H.T. / shielding / cooling / low (cathode) voltage or L.T.

3
3
3
3

12

What are X-rays and how do they differ from light rays?

what: electromagnetic radiation / photons / quanta of energy

6

high frequency / short wavelength / high energy

3

how: x-rays penetrate matter / cause ionization / any valid comparative property

3

Give two uses of X-rays.

(medical) analysis of bone structure/ luggage scanners (at airports) / any specific medical,
industrial or security use, etc.

any two

2×3

18

When electrons hit the target in an X-ray tube, only a small percentage of their energy is converted into X-rays. **What happens to the rest of their energy and how does this influence the type of target used?**

converted to heat
target material must have (very) high melting point / (specific example, e.g.) tungsten

6
3

9

A potential difference (voltage) of 40 kV is applied across an X-ray tube.

Calculate:

- (i) **the maximum energy of an electron as it hits the target**

$$W = qV$$

3

$$W = (1.6 \times 10^{-19})(40 \times 10^3) = 6.4 \times 10^{-15} \text{ J}$$

3

(-1 for omission of or incorrect units)

- (ii) **the frequency of the most energetic X-ray produced.**

$$E = hf$$

3

$$f = \frac{6.4 \times 10^{-15}}{6.6 \times 10^{-34}} = 9.7 \times 10^{18} \text{ Hz}$$

2

(-1 for omission of or incorrect units)

11

Question 10

Answer **either** part (a) or part (b).

(a)

(i) **What is anti-matter?**

material/matter/particle that has same mass as another particle 3
 (but equal in magnitude and) opposite charge 3

An anti-matter particle was first discovered during the study of cosmic rays in 1932.

Name the anti-particle and give its symbol.

positron / anti-electron 3

$e^+ / \beta^+ / \bar{e}$ 3

What happens when a particle meets its anti-particle?

(entire) mass converted to / pair annihilation occurs (followed by creation of) 3

energy / photon(s) 3

(ii) **What is meant by pair production?**

particle and (its) antiparticle created 3

from energy / gamma rays 3

(the production of a positron and an electron from a gamma ray photon ... 6 marks)

A photon of frequency 3.6×10^{20} Hz causes pair production. Calculate the kinetic energy of one of the particles produced, each of which has a rest mass of 9.1×10^{-31} kg.

For photon: $E = hf$ / $E = (6.6 \times 10^{-34}) [3.6 \times 10^{20}] / 2.376 \times 10^{-13}$ (J) 3

$E = mc^2$ / $E = 2mc^2$ 3

$E = 2(9.1 \times 10^{-31}) (3.0 \times 10^8)^2 / = 1.638 \times 10^{-13}$ (J) 3

$\Delta E = [2.376 - 1.638] 10^{-13} / 7.38 \times 10^{-14}$ 3

E_k per particle = 3.69×10^{-14} J

(-1 for omission of or incorrect units)

21

(iii) A member of a meson family consists of two particles. Each particle is composed of up and down quarks and their anti-particles.

Construct the possible combinations. Deduce the charge of each combination and identify each combination.

composition	charge	name	
$u + \bar{u} \Rightarrow 0$	$\Rightarrow \pi^0$	pi-neutrino	composition 4 x 1
$u + \bar{d} \Rightarrow +1$	$\Rightarrow \pi^+$	pi-plus	
$d + \bar{u} \Rightarrow -1$	$\Rightarrow \pi^-$	pi-minus	charge 4 x 1
$d + \bar{d} \Rightarrow 0$	$\Rightarrow \pi^0$	pi-neutrino	name 4 x 1

(award 4 marks for collective name 'pions')

What famous Irish writer first thought up the name 'quark'?

(James) Joyce

5

17

(b)

Distinguish between intrinsic conduction and extrinsic conduction in a semiconductor.

intrinsic conduction:

pure semiconductor/pure silicon 3
equal number of electrons and (positive) holes 3

extrinsic conduction:

doped/impure semiconductor // reference to majority/minority charge carriers 3

9

The circuit shows four light-emitting diodes connected to a resistor R and a 6 V a.c. supply of frequency 1 Hz.

(i) What is observed when the circuit is operating?

during one second/cycle 3

D_1 and D_4 flash (together during one half cycle) 3

followed by D_2 and D_3 (flashing) 3

(two leds flash at any one instant ... 6 marks: leds flash on and off ... 3 marks)

Explain what is observed by referring to the circuit.

when D_1 and D_4 are forward biased (and so they will conduct) 3

D_2 and D_3 are reverse biased 3

(two of the leds are only forward biased every half cycle/second ... 6 marks)

What is observed when the frequency of the a.c. supply is increased to 50 Hz?

(flash so fast that) leds (appear to) light continuously 3

18

(ii) Give two functions of the resistor R?

protects leds (from over-load) / limits the current 3

(acts as a) load (resistor) 3

How was the output voltage displayed?

cathode ray oscilloscope / c.r.o. / computer (monitor) / datalogger 6

Draw graphs to show the differences between the input voltage and the output voltage.

(in phase) a.c input 6

full wave rectified output (in phase) 6

24

(iii) It is noticed that the output voltage is lower than the input voltage. Explain why.

voltage drop across a led (≈ 1.6 V) / '(some) voltage lost across leds'

/ some reference to 'energy conversion' 5

5

Question 11

(a) Give two properties of radio waves.

travel at speed of light; electromagnetic radiation; travel through vacuum;
(can be) reflected; refracted; polarized; etc.

any two: 4+3

(b) In a three-minute phone call, 10 g of head tissue absorbs 0.36 J of radio frequency energy. Calculate the SAR value.

$$(\text{Power}) = \frac{0.36}{3 \times 60} \text{ (J s}^{-1}\text{)} \quad / = 0.002 \text{ (W)} \quad 4$$

$$\text{SAR} \left(\Rightarrow \frac{\text{W}}{\text{kg}} \right) = \frac{0.36}{(3 \times 60) (10 \times 10^{-3})} \quad / 0.20 \text{ (W kg}^{-1}\text{)} \quad 3$$

(c) What happens to the radio frequency energy absorbed by the body?

converted into heat

4

carried away by the body

3

(d) Why are radio frequency waves not very penetrating?

low frequency / long wavelength / low energy

7

(e) A mobile phone converts the received radio frequency waves to sound waves.

What are the audible frequency limits for sound waves?

(lower value \approx) 20 Hz

4

(upper value \approx) 20 000 Hz

(-1 for omission of or incorrect units) 3

(f) Give two safety precautions you should take when using a mobile phone.

keep phone at distance / use loudspeaker function / 'no hands etc.:

brief calls only: direct antenna away from your head: etc.

any two: 4+3

(g) A mobile phone transmits at 1200 MHz from its antenna.

Calculate the length of its antenna, which is one quarter of the wavelength that it transmits.

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{1.2 \times 10^9} \quad / 0.25 \text{ (m)} \quad 4$$

$$\text{length of antenna} = 0.0625 \approx 0.06 \text{ m} \quad (-1 \text{ for omission of or incorrect units}) \quad 3$$

(h) Name an electromagnetic wave which may induce cancer. Justify your answer.

γ rays / X-rays / UV

any one: 4

ionization of (body) cells

3

Question 12

(a)

(i) A student holds a motion sensor attached to a data-logger and its calculator. **List the instructions you should give the student so that the calculator will display the graph shown in Figure 1.**

- stand 1 m from wall (and select *START*) 3
- stationary for 5 s 3
- move back to 3 m (from wall) in 6 s / accept specific velocity and time/distance 3
- stationary for 7 s 3
- approach to 1 m in 4 s 2

14

(ii) **Using the graph, calculate the distance travelled by the cyclist and the average speed for the journey.**

$$18 \text{ km h}^{-1} \left[= \frac{18000}{60} \right] = 300 \text{ m min}^{-1} \quad 2$$

$$s_1 = (\text{average speed} \times \text{time}) = 150 \times 6 = 900 \text{ (m)} \quad 2$$

$$s_2 = 300 \times 8 = 2400 \text{ (m)} \quad 2$$

$$s_3 = 150 \times 5 = 750 \text{ (m)} \quad 2$$

$$\text{total distance} = 4050 \text{ (m)} \quad 2$$

$$\text{averagespeed} = \frac{(\text{total})\text{distance}}{(\text{total})\text{time}} \quad 2$$

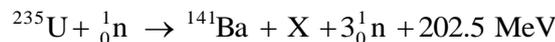
$$\text{averagespeed} = \frac{4050}{19} / 213.2 \text{ m min}^{-1} / 3.55 \text{ m s}^{-1} \quad 2$$

(–1 for omission of or incorrect units)

14

(b)

The following reaction occurs in a nuclear reactor:



(i) **Identify the element X.**

Kr / krypton

6

6

(ii) **Calculate the mass difference between the reactants and the products in the reaction.**

$$E = mc^2 \quad 3$$

$$m = \frac{(202.5 \times 10^6)(1.6 \times 10^{-19})}{(3 \times 10^8)^2} \quad 3$$

$$m = 3.6 \times 10^{-28} \text{ kg} \quad 3$$

(–1 for omission of or incorrect units)

9

(iii) **What is a chain reaction?**

self-sustaining reaction / reaction where fission neutrons produce further fission (giving more neutrons) etc. / clear diagrammatic representation

6

Give one condition necessary for a chain reaction to occur.

mass of fuel present exceeds the critical mass / at least one of the neutrons released must cause fission of another nucleus

9

(iv) **Give one environmental impact associated with a nuclear reactor.**

toxic / radioactive waste, exposure to radiation, etc.

4

4

(c)

Explain the term resonance and describe a laboratory experiment to demonstrate it.

transfer of energy (state/imply) 3
so that a body vibrates at its natural frequency 3

Exemplar:

apparatus: tuning fork, length of pipe (with means of varying length) 3
procedure: hold vibrating fork over (open) end of pipe and vary length (of air column) 3
observation: loud sound is heard (at certain length) 3

15

Give two characteristics of a musical note and name the physical property on which each characteristic depends.

pitch▶ frequency 3
loud▶ amplitude / intensity 3
quality/timbre▶ harmonics / overtones 3

3×3
9

(award **3 marks** for each of two 'characteristics' and a further **3 marks** if the associated properties are correct for both)

Explain why a musical tune does not sound the same when played on different instruments.

different instruments emit (a fundamental frequency plus) different (combinations of) overtones/harmonics 4

('a closed pipe emits odd multiples of a fundamental frequency whereas an open pipe emits all multiples of the fundamental frequency' 4 marks) 4

(d)

Define electric field strength and give its unit of measurement.

force // $E = F / q$ 3

per unit charge // correct notation 3

$\text{N C}^{-1} / \text{V m}^{-1}$ 3

Copy the diagram into your answerbook and show on it the direction of the electric field at point P.



Calculate the electric field strength at P.

$$E = \frac{q}{4\pi\epsilon d^2} \quad / \quad F = \frac{q_1 q_2}{4\pi\epsilon d^2} \quad 3$$

$$\text{total field at P: } E_{\text{total}} = \frac{1}{4\pi\epsilon} \left[\frac{q_1}{d_1^2} + \frac{q_2}{d_2^2} \right] \quad 3$$

$$E_{\text{total}} = \frac{1}{4\pi\epsilon} \left[\frac{2 \times 10^{-6}}{(0.1)^2} + \frac{5 \times 10^{-6}}{(0.15)^2} \right] \quad 3$$

$$E_{\text{total}} = 3.77 \times 10^6 \text{ N C}^{-1} \quad (\text{direction indicated})$$

(-1 for omission of or incorrect units) 15

Under what circumstances will point discharge occur?

large electric field strength / potential at a point / high charge density at a point 4

4

