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GCE

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Physics (6733/01)

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Mark Scheme (Results)

Edexcel GCE
Physics (6733/01)

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Notes on the Mark Schemes

1. *Alternative responses:* There was often more than one correct response to a particular question and these published mark schemes do not give *all* possible alternatives. They generally show only the schemes for the most common responses given by candidates. They are **not** model answers but indicate what the Examiners accepted in this examination.

2. *Error carried forward:* In general, an error made in an early part of a question is penalised there but not subsequently, i.e. candidates are penalised once only, and can gain credit in later parts of a question by correct reasoning from an earlier incorrect answer.

3. *Quantity algebra:* The working for calculations is presented using quantity algebra in the mark schemes for Units PHY1, PHY2, PHY3 (Topics), PHY4, PHY5/01, and PHY6 but candidates are not required to do this in their answers.

4. *Significant figures:* Use of an inappropriate number of significant figures in the theory papers will normally be penalised only in "show that" questions where too few significant figures has resulted in the candidate not demonstrating the validity of the given answer. Use of an inappropriate number of significant figures will normally be penalised in the practical tests. In general candidates should nevertheless be guided by the numbers of significant figures in the data provided in the question.

5. *Unit penalties:* A wrong or missing unit in the answer to a calculation will generally lose one mark unless otherwise indicated.

6. *Quality of written communication:* Each theory paper will usually have 1 or 2 marks for the quality of written communication. The mark will sometimes be a separate mark and sometimes be an option in a list of marking points.

Within the schemes:

- / indicates alternative marking point
  ( ) brackets indicate words not essential to the answer
  [ ] brackets indicate additional guidance for markers

- The following standard abbreviations are used:

a.e.	arithmetic error (−1 mark)
e.c.f.	error carried forward (allow mark(s))
s.f.	significant figures (−1 mark only where specified)
no u.e.	no unit error

6733 Unit Test PHY3 (Topics)

Topic A - Astrophysics

(a) Background wavelength

Use of $\lambda_{max} T = 2.90 \times 10^{-3}$ m K ✓

Correct substitution ✓

1.06 (or 1.1) $\times 10^{-3}$ m ✓ **3**

Part of spectrum

Microwave or infra-red ✓ **1**

(b) Main sequence star definition

(Fusion of) hydrogen (nuclei) / protons to helium (nuclei) ✓

stably / in equilibrium / in core ✓ **2**

Hertzsprung-Russell diagram

Diagonal falling line ✓

Correct curvature above 20 000 K **and** below 5000 K ✓ **2**

X on line and level with 10^0 (to $\pm$ 1 mm) [must be clearly indicated] ✓ **1**

Dwarfs and Giants

(i) bottom left quadrant ✓

(ii) top right quadrant ✓

[no region indicated max. ✓ **x**]

T consistent with diagram at centre of region **and** $2500 \leq T/K \leq 10000$ ✓ **3**

(c) More MS stars

(i) γ Cas	✓	
(ii) α Cen B	✓	**2**
Diameter of Sirius A		
$26 \times 3.9 \times 10^{26}$	✓	
1.0×10^{28} W (ue)	✓	**2**
$L = \sigma T^4 A$ (or implied by substitution)	✓	
A = 2.46 (or 2.43 or 2.45) $\times 10^{19}$ (m^2)	✓	**2**
Use of πd^2 / $4\pi r^2$ / 1.4×10^9 m	✓	
2.8×10^9 m [no ecf]	✓	**2**

(d) Supernova processes

Quality of written communication	✓	
Heavier elements fused / fusion occurs in outer shells (around core)	✓	
Runs out of fuel to fuse/fusion ceases thus implosion / core collapse	✓	
Protons + electrons form neutrons OR Shock wave (or explosion) blows away outer layers	✓	
Neutron star / pulsar / black hole	✓	**5**

(e) Hydrogen fusion

Mass subtraction of 4p – He	✓	
4.7×10^{-29} (kg)	✓	**2**
$E = mc^2$ seen/implied	✓	
4.2 (or 4.5) $\times 10^{-12}$ J	✓	**2**
Percentage mass loss		
4.7×10^{-29} divided by $4 \times 1.673 \times 10^{-27}$ (allow 5×10^{-29} or 6.645×10^{-27})	✓	
7×10^{-3}	✓	
% conversion: 0.7% / 0.75% (ecf)	✓	**3**
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Topic B - Solid Materials

(a)(i) Young modulus

Any reference to gradient or E = stress / strain [or implied]	✓	
Substitution of correct values for either straight line [to $\pm$ 1 mm]	✓	
$1.25 – 1.45 \times 10^{11}$ and $\geq$ 3.s.f	✓	**3**

(ii) Energy density

Any area attempted	✓	
Triangle area: ½ × 300 × 1.5 or 13.5 cm^2 squares [or equivalent area chosen]	✓	
Rectangle area: 300 × 1.5 or each of 100 (MPa)	✓	
6.5 – 7.0 and 10^5 ($J\ m^{-3}$)	✓	**4**

Strongest material

A	✓	
Highest UTS / tensile stress	✓	**2**

(b) Crosses and materials

Three crosses at end of straight line regions	✓	
A = high carbon steel		
B = mild steel		
C = copper		
All correct [1 or 2 correct score ✓ **x**]	✓ ✓	
High carbon steel / A [if A = h.c.s.]	✓	**4**

Molecular structure of metals

Quality of written communication	✓	
Elastic – atomic separation increases **and** reversible / atoms do not change (relative) position	✓	
Plastic – bonds between atoms broken / dislocations move / atoms change position permanently / relatively	✓	
Fracture – plane of bonds break	✓	**4**

	Rubber line to scale		
	(Horizontal) line starting from origin (max 40 MPa at 3.0×10^{-3})	✓	**1**
(c)	Pre-stressed reinforced concrete beam		
	Steel / iron **and** rod / cable / wire	✓	
	Tension / loaded / stressed	✓	
	Concrete cast / poured over (not cement) **and** allowed to set / solidify	✓	
	Tension forces removed [NOT rods contract]	✓	
	(Leaving) steel in tension **and** concrete in compression	✓	**5**
(d)	Elastomer		
	Materials which can be stretched considerably / to high strain (or >100%) AND still return to their original length when stress is removed	✓	**1**
	Molecular structure of rubber		
	Tangled chain molecules	✓	
	(Easy to stretch at start) chains are straightened out	✓	
	(Harder to stretch when) straight chains (or bonds) being stretched	✓	**3**
(e)	Castle drawbridge		
	W = 19 620 N / 20 000 N	✓	
	Weight acting at 1.5 m, vertically downwards	✓	**2**
	Principle of moments stated or implied ["in equilibrium" not required]	✓	
	Substitution with cos 45° or sin 45° (allow $2T$ here, ecf)	✓	
	7 kN (no ecf)	✓	**3**
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Topic C - Nuclear and Particle Physics

(a) Neutron Capture Equation

$^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{92}U$ ✓ **1**

Beta minus decay

$^{239}_{92}U \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}\beta + \bar{\upsilon}$

$U \rightarrow Np + \beta^-$ ✓

Hence all six numbers correct ✓

antineutrino ✓ **3**

(b)(i) Binding energy per nucleon graph

Nucleon number / mass number ✓ **1**

(ii) Nuclei *on* graph

H at start of curve (< 3 MeV), Fe at peak of curve (at 56), U at end of curve (at 235) [to ± 1mm]

any two ✓

all three ✓

(iii) Fe (ecf) ✓ **3**

(iv) Binding energy of U

7.5 / 7.6 (ecf) ✓

x 235 ✓

1.8 (GeV) [allow 1.76 – 1.80, no e.c.f] ✓ **3**

(c) Positronium charge and mass

neutral / zero ✓

charges of +1 AND -1 cancel ✓ **2**

Electron and positron are antimatter versions of each other ✓ **1**

Antimatter interaction

Annihilation ✓

γ / energy / photon ✓ **2**

Possible interactions

Quality of written communication ✓

Electromagnetic force affects charged particles – hence yes ✓

Weak force affects all particles C hence yes ✓

Gravitational force negligible / affects masses hence yes OR strong force affects quarks / hadrons only hence no ✓

Similarities and differences **4**

Any two from: Made of matter and antimatter / short lifetime / unstable / neutral charge [not made of fundamental particles] ✓✓

Lepton vs. quarks / different mass / meson affected by strong force ✓

3

(d) Conservation laws

Baryon ✓

-1 ✓

Q: (-1) + (+1) = (0) + (+1) + (X) ✓

B: (0) + (+1) = (0) + (0) + (X) ✓ **4**

Quark content

uud ✓

$u\bar{s}$ ✓

2

Particle X

Quark equation ($s\bar{u}$ + uud → $d\bar{s}$ + $u\bar{s}$ + X) [allow ecf] ✓

Correct cancelling of quark flavours ✓

sss ['sss' alone scores 3/3] ✓

3

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Topic D - Medical Physics

(a)	Radiation effects on cells		
	Destruction / kills cells [not just damage]	✓	
	Mutation	✓	**2**
(b)	Nuclear equation		
	Correct symbols: $I \rightarrow Xe + \beta + \gamma$	✓	
	0 and -1 for β	✓	
	131, 53 **and** 131, 54 correct for I and Xe	✓	**3**
(c)	Technetium symbols		
	metastable / excited state	✓	
	will emit γ / energy / photon	✓	**2**
	Time scale		
	One day per cycle	✓	**1**
	Elution graph shape		
	Quality of written communication	✓	
	(Rise:) Mo decays to generate Tc	✓	
	(Fall:) "milking" of cell / elution process / Tc flushed out / Tc removed from cell	✓	
	Peak height falls as Mo decays	✓	**4**
(d)	Nature of ultrasound		
	High frequency (wave / sound) / frequency above human hearing	✓	
	Above 20 000 Hz [or correct example given]	✓	**2**

Sonar principle

Pulse / short ultrasound wave sent ✓

Detect echo / reflection ✓

(Information gained from) time delay / signal amplitude ✓ **3**

Specific acoustic impedance of soft tissue

Use of $c = f\lambda$ and $\times 10^6$, 10^{-3} conversion ✓

1545 / 1550 (m s^{-1}) ✓ **2**

Correct substitution in $Z = cp$ ✓

1.64×10^6 kg m^{-2} s^{-1} [allow 1.59×10^6 kg m^{-2} s^{-1}] ✓ **2**

Percentage transmission

Use of α ✓

Substitution (should be $(4.9/8.1)^2$, ecf their Z) ✓

0.36 / 0.37 [no ecf, beware 60% from incorrect equation] ✓

64% / 63% [ecf on reflected value] ✓ **4**

(e) X-ray energy

Diagnosis keV AND therapy MeV ✓

Any point from: keV: Preferential absorption / Z dependence for absorption [or MeV absorption not Z dependent] ✓

MeV: More penetrating / kill cells ✓ **3**

X-ray image explanation

White = bone **and** grey (allow black or darker areas) = soft tissue ✓

White = no X-rays reach film (to darken it) / Grey = some X-rays reach film (to darken some of it) ✓

Attenuation / absorption (strongly) dependent on proton number ✓

20 > 9 (or implied) means greater attenuation for bone than tissue ✓ **4**

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