GCSE
PHYSICS

Topic Paper: 4.4 & 8.1.2 Nuclear fission and fusion and The life cycle of a star (Physics only)
Part 1 & 2 Mark Scheme

MARK SCHEME

68 Marks

M1. formed from dust or gas (unless in atmosphere) which is pulled together by gravitational forces high temperature inside

[2]

M2. (a) (i) plutonium (239)

accept Pu / Thorium / MOX (mixed oxide)
*do **not** accept uranium-238 **or** hydrogen*

1

(ii) (energy) used to heat water and

1

produce (high pressure) steam

1

the steam drives a turbine (which turns a generator)

1

(b) Neutron(s) shown 'hitting' other U-235 nuclei
one uranium nucleus is sufficient

1

U-235 nuclei (splitting) producing 2 or more neutrons

1

(c) any **two** from:

neutrons are absorbed (by boron / control rods)

there are fewer neutrons

chain reaction slows down / stops
accept fewer reactions occur

2

[8]

M3. (a) (i) (large) nucleus hit by a neutron

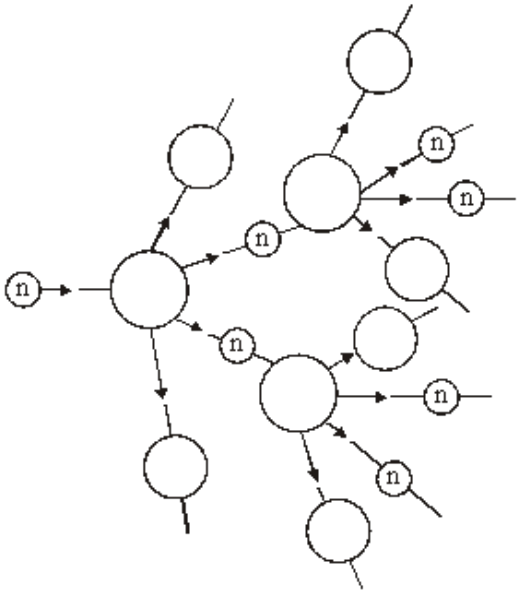
1

splits into (smaller) nuclei **and** neutron(s) (+ energy)

1

(ii) additional neutrons collide with nuclei causing further fission

allow full credit for a correct labelled diagram
accept 2 or more neutrons given out at each fission reaction
diagram shows 3 discernible sizes, with smaller nuclei and neutrons at same stage



1

(b) cost of (building and) de-commissioning is very high **or**
cost of building is higher

accept a correct description of de-commissioning
accept high cost to keep the power station safe / secure
accept high cost of reprocessing / storage of nuclear waste

1

(c) less pollution from transport carrying the fuel

accept coal produces more pollutant gases
accept correct named gases
accept more radiation pollution from coal than nuclear
accept more waste from coal than nuclear
*do **not** accept any reference to burning uranium*
*do **not** accept answers in terms of global warming **or** acid rain unless developed*

1

[5]

M4. (a) it use $E = mc^2$

mass in kg i.e. $0.001 \times \frac{0.7}{100}$

each gains 1 mark

but 000007

gains 2 marks

2.1×10^{3}

gains 3 marks

evidence of 0.000007

mass in kg (i.e. 0.0007 **or** 0.7/100000)

each gains 1 mark

squaring the speed of light

but 6.3×10^{11} *(credit alternative ways of stating this)*

gains 3 marks

units J/joule

for 1 further mark

(N.B credit kJ, MJ, GJ but check power of 10 for full credit)

4

(b) (i) *idea that* the bigger the mass the shorter the life

gains 1 mark

but *idea that* decrease in life is much more than proportional to increase in mass

or more than proportional to $mass^2$

gains 2 marks

2

(ii) *ideas that*:

greater mass means greater **core** temperature/pressure

greater core temperature/pressure means greater rate of fusion

increase in mass produces a proportionally much greater increase in the rate of fusion

each for 1 mark

3

[9]

M5. (a) any **two** from:

nuclei / atoms of light elements fuse

accept hydrogen or helium for light elements
accept join for fuse
*accept for **1** mark, by nuclear fusion*
answers about fission negates a mark

each (fusion) reaction releases energy / heat / light

lots of reactions occur

2

(b) presence of nuclei of the heaviest / heavy / heavier elements

accept atom for nuclei

1

(c) (i) (matter / mass) with such a high density / strong gravitational (field)

1

electromagnetic radiation / light is pulled in

accept nothing can escape
*do **not** accept answers in terms of an empty void*

1

(ii) X-rays

accept e-m radiation / e-m waves

1

[6]

M6. (a) runs out of hydrogen (in its core)

accept nuclear fusion slows down
*do **not** accept fuel for hydrogen*
*do **not** accept nuclear fusion stops*
ignore reference to radiation pressure / unbalanced forces

1

(b) temperature decreases / (relative)luminosity increases as it changes to a red giant

if both temperature and luminosity are given both must be correct

1

temperature increases / (relative) luminosity decreases as it changes to a white dwarf

if both temperature and luminosity are given both must be correct

1

correct change in temperature **and** (relative) luminosity as Sun changes to a red giant and then to a white dwarf

*an answer changes to a red giant and then white dwarf with no mention or an incorrect mention of temperature or (relative) luminosity change gains **1** mark only if no other marks awarded*

ignore correct or incorrect stages given beyond white dwarf

1

[4]

M7. (a) (i) (nuclear) fission

*accept fision providing clearly **not** fusion*

1

(ii) (released) neutrons are absorbed by further (uranium) nuclei

accept hit nuclei for absorbed / hit
*do **not** accept atom for nuclei*

1

more neutrons are released (when new nuclei split)

*accept for **both** marks a correctly drawn diagram*

1

(iii) increases by 1

or goes up to 236

1

(b) any **two** from:

(more) neutrons are absorbed

accept there are fewer neutrons

(chain) reaction slows down / stops

accept keeping the (chain) reaction controlled

less energy released

accept heat for energy
accept gases (from reactor) are not as hot

2

[6]

M8. (a) (i) the bigger the masses (of the dust and gases then) the bigger the force / gravity (between them)

accept the converse

1

(ii) the greater the distance (between the dust and gases then) the smaller the force / gravity (between them)

accept the converse

1

(b) radiation 'pressure' and gravity / gravitational attraction
these are balanced / in equilibrium

1

must be in correct context
*do **not** accept are equal*

or there is sufficient / a lot of hydrogen / fuel to last a very long time
second mark consequent on first

1

(c) any **two** from:

hydrogen runs out / is used up

nuclei larger than helium nuclei formed
*accept bigger atoms are formed however do **not** accept any specific mention of an atom with a mass greater than that of iron*

(star expands to) / become(s) a red giant

2

[6]

M9. (a) gravitational attraction
accept 'gravity'
accept (nuclear) fusion

1

(b) radiation 'pressure' and gravity / gravitational attraction
must be in correct context

1

are balanced / in equilibrium
accept are equal and opposite
*do **not** accept 'equal'*
or
there is sufficient / a lot of hydrogen / fuel
*do **not** accept constant supply of hydrogen*

to last a very long time / for (nuclear) fusion
this mark only scores if linked to the supply of hydrogen / fuel
reference to burning negates both marks

1

(c) (i) (conversion of) hydrogen to helium
accept (conversion of) lighter elements to heavier elements

1

by (nuclear) fusion
*note do **not** credit spelling of 'fusion' which could be 'fission'*
reference to burning negates both marks

1

(ii) massive supply / lots of hydrogen

1

(d) distributed throughout the Universe / space

*do **not** accept Solar System for Universe*

1

[7]

M10. (a) (forces due to) gravity and radiation pressure

1

correct direction of forces

1

(forces) are balanced / equilibrium / equal

*accept for **3** marks an answer in terms of*
sufficient hydrogen (1)
to keep fusion reaction (1)
reference to burn / burning negates this mark
going at a continuous /steady rate (1)
*if fuel is used instead of hydrogen maximum of **2** marks*

1

(b) the Sun will remain stable (for several billion years)

1

based on evidence

accept a specific example of evidence
eg that the Sun has remained stable during the life of our planet / for 4.5 billion years
or
still contains more than 50 % hydrogen
or
by comparison with the lifecycle of (similar) stars
allow a refutation
eg not based on prejudice / whim / hearsay / folk law / historical or religious authority

1

[5]

M11. (a) fusion

*do **not** credit any response which looks like 'fission'*

1

of hydrogen / H (atoms)

credit only if 1st mark point scores

1

(b) fusion of other / lighter atoms / elements

reference to big bang nullifies both marks

1

during supernova / explosion of star(s)

1

(c) the (available) evidence: supports this idea
or
does not contradict this idea
or
can be extrapolated to this idea
or
(electromagnetic) spectrum from other stars is similar to sun

1

[5]

M12. (a) a protostar is at a lower temperature
or
a protostar does not emit radiation /energy

1

as (nuclear) fusion reactions have not started

accept heat or light for energy

1

(b) by (nuclear) fusion

accept nuclei fuse (together)

nuclear fusion and fission negates this mark

1

of hydrogen to helium

1

elements heavier than <u>iron</u> are formed in a <u>supernova</u>

accept a specific example e.g. heavier elements such as gold are formed in a supernova

accept heavier elements (up to iron) formed in red giant/red super giant

reference to burning (hydrogen) negates the first 2 marks

1

[5]