

Name of the Student: _____

Max. Marks : 21 Marks

Time : 21 Minutes

Mark Schemes

Q1.

- (a) **The student's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The student's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

Student names strong, weak and electromagnetic interactions. Identifies that only hadrons experience the strong interaction but hadrons and leptons experience weak interaction. Charged particles experience electromagnetic interaction. Is able to identify all exchange particles such as gluons, W^+ and W^- and virtual photons. Gives examples of two of the interactions i.e. electrons repelling, electron capture, beta decay.

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

Student names strong, weak and electromagnetic interactions. Identifies that only hadrons experience the strong interaction but hadrons and leptons experience weak interaction. Charged particles experience electromagnetic interaction. Is able to identify some exchange particles such as gluons, W^+ and W^- and virtual photons.

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

Student names strong, weak and electromagnetic interactions. Identifies that only hadrons experience the strong interaction. Identifies one exchange particle.

The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.

*Names of interactions – strong, weak and electromagnetic
hadrons experience strong
hadrons and leptons experience weak
charged particles experience electromagnetic*

identify exchange particles

give examples of various interactions e.g. electron capture

(either weak interaction or electromagnetic or strong interaction)

first mark conservation at left hand junction of charge, baryon and lepton number ✓

second mark conservation at right hand junction of charge, baryon and lepton number

✓

third mark for correct exchange particle ✓

ignore any reference to gravity

ignore any Feynman diagrams electrostatic not allowed as alternative for electromagnetic

Properties of interactions

- correct exchange particle ($W^{+/-}$ boson / Z_0 boson, (virtual) photon, gluon / pion) NB sign on W not required
- correct group of particles affected (strong: baryons and mesons, weak: baryons, mesons and leptons, electromagnetic: charged particles)
- example of the interaction

Lower band

1 mark – two interactions OR one interaction and one property for that interaction

2 marks – two interactions and one property for one interaction

Middle band

3 marks – two interactions plus two properties

4 marks – two interactions plus minimum of four properties (e.g. 3 props plus 1 OR 2 props plus 2), if three interactions quoted then properties can be spread between the 3 e.g. one property for each (3) plus one additional

Top band

5 marks – 3 interactions plus two properties for each

6 marks – must give first two properties for all three interactions AND correctly state two examples of interactions e.g. electron capture example of weak, strong nuclear responsible for binding protons / neutrons / baryons together

A table may help:

	strong	weak	EM
property 1			
property 2			
property 3			

(b)

if exchange particle not identified but baryon and lepton numbers conserved on both sides – 1 mark

ignore orientation of line showing exchange particle or any arrows on exchange particle line when awarding first two marks

if arrows on incoming and outgoing interacting particles in wrong direction then lose mark

if lines do not meet at a junction lose 1 mark

with third mark orientation of exchange

particle line must be consistent with exchange particle shown and no arrow required
 if exchange particle line is horizontal (for weak) then must be a correct arrow
 arrow overrides slope

3

[9]

Q2.

- (a) (i) the minimum energy required by an electron ✓
 to escape from a (metal)surface ✓

if refer to atom / ionisation zero marks

2

- (ii) the (minimum) energy to remove an electron (from an atom) ✓
 from the ground state ✓

2

- (b) (use of $hf = eV$)

$$6.63 \times 10^{-34} \times f = 5.15 \times 1.60 \times 10^{-19} \checkmark$$

$$f = \frac{5.15 \times 1.60 \times 10^{-19}}{6.63 \times 10^{-34}} \checkmark = 1.24 \times 10^{15} (\text{Hz})$$

if no working and $1.24 \times 10^{15} (\text{Hz})$ 1 mark

2

- (c) (use of $hf = E_k + \Phi$)

$$\Phi = 2.28 \times 1.60 \times 10^{-19} = 3.648 \times 10^{-19} (\text{J}) \checkmark$$

$$E_k = 5.15 \times 1.60 \times 10^{-19} - 3.648 \times 10^{-19} = 4.59 \times 10^{-19} \text{ J} \checkmark \checkmark$$

3 sig figs

if clearly used 1.2×10^{15} then final answer must be to 2 sig. figs. for last mark to be awarded

accept 4.57 in place of 4.59

3

- (d) (use of $c = f\lambda$)

$$\lambda = \frac{3.0 \times 10^8}{1.24 \times 10^{15}} = 2.42 \times 10^{-7} \checkmark$$

$$v = h / m\lambda = 6.63 \times 10^{-34} / (9.11 \times 10^{-31} \times 2.42 \times 10^{-7})$$

$$v = 3010 \text{ m s}^{-1} \checkmark \checkmark$$

first mark minimum working – determination of wavelength

bald answer gets 2 marks

range to 3 sig figs 2900 – 3030

3

[12]