Name of the Student:_____
Max. Marks : 19 Marks **Time : 19 Minutes**

Mark Schemes

Q1.

(a) 2.0 cm ✔ (allow 1.96 to 2.00 cm)

(Answer alone gains mark and ignore number of sig. figs)

(The depth halves in 19s. With the graph being exponential the depth will halve every 19s. 57/19 = 3 so the halving occurs 3 times. 16 cm → 8 cm → 4 cm → 2 cm)

1

(b) Use more water/greater depth/greater volume (in the existing cylinder)

(This should give the same half-life) ✔

Assume the word water is present in the answer if there is no reference to it. Eg 'greater depth' is taken as 'greater depth of water'.

1

(c) Closing the tap more

OR

Using a more viscous fluid (density is not the same as viscosity)

OR

Using a wider cylinder

OR

Use a smaller diameter capillary/narrow tube ✔

To decrease the decay constant the depth decrease rate should be reduced ie the cylinder should take longer to empty).

Changes to the tube need to be specific.

Also tube needs to be identified.

1

(d) (Using $T_{½} = \ln 2/\lambda = 0.693/1.42 \times 10^{-11}$)

$T_{½} = 4.9(4.88) \times 10^{10}$ (year) ✔

1

(e) (Use of $N = N_o e^{-\lambda t}$ mass is proportional to number so

$m = m_o e^{-\lambda t}$

$m_o = m\, e^{+\lambda t}$)

$\lambda t = 1.42 \times 10^{-11} \times 4.47 \times 10^{9}$ or 0.0635 ✔

($m_o = 1.23 \times 10^{-3}\, e^{1.42 \times 10_{-11} \times 4.47 \times 10_{9}}$)

$m_o = 1.31 \times 10^{-3}$ (g) ✔(allow and look out for unit being modified to mg)

Mark for 3 sig figs but must be attached to a final answer for mass with some attempt at a relevant exponential calculation ✔

May calculate N = 8.51(2) × 10^{18} and N_0 9.07 × 10^{18} but marks will be the same.

3

(f) (N = mass/87u = 1.23 × 10^{-6} /(87 × 1.661 × 10^{-27})

$N = 8.5(1) \times 10^{18}$ ✔

(This does not have to be calculated out for the mark)

($\lambda = 1.42 \times 10^{-11}$ / (365 × 24 × 60 × 60) = 4.50 × 10^{-19})

($A = \lambda N = 4.50 \times 10^{-19} \times 8.51 \times 10^{18}$)

A = 3.8(4) ✔ (this calculation must use in seconds)

Bq, B/becquerel, counts s^{-1} or s^{-1} ✔

In first mark is obtainable from calculating number of moles and then multiplying by Avogadro's number.

{n = 1.23 × 10^{-6}/87 = 1.41 × 10^{-5}

N = 1.41 × 10^{-5} × 6.02 × 10^{23}}

A power of 10 error will count as an AE and will allow an error carried forward.

Answer must follow working showing correct process as correct answer can come from incorrect working.

3

[10]

Q2.

(a) (using mass defect = Δm = Z m_p + N m_n – M_{Co})

Δm = 27 × 1.00728 + 32 × 1.00867 – 58.93320 (u) ✔

Δm = 0.5408 (u) ✔

Binding Energy = 0.5408 × 931.5 = 503.8 (MeV) ✔ (CE this mark stands alone for the correct energy conversion even if more circular routes are followed.

Look at use of first equation and if electrons are used or mass of proton and neutron confused score = 0.

If subtraction is the wrong way round lose 1 mark.

Data may come from rest mass eg m_n =939.551 MeV or 1.675 × 10^{-27} kg or 1.00867 u.

So if kg route used Δm = 8.83 × 10^{-28} kg BE = 7.95 × 10^{-28} J and 497 Mev.

Conversion mark (2nd) may come from a wrong value worked through. 0.47(5)

3

(b) $(2.52 – 1.76) \times 10^{-13} = 7.6 \times 10^{-14}$ J ✔

$7.6 \times 10^{-14} / 1.60 \times 10^{-13} = 0.47$ or 0.48 MeV ✔(0.475 MeV)

Correct answer scores both marks.

2

(c) 6 (specific wavelengths)

1

(d) (longest wavelength = lowest frequency = smallest energy)

$(2.29 \times 10^{-13} – 2.06 \times 10^{-13}) = 2.3 \times 10^{-14}$ (J) ✔

λ (= $h\,c / E$) $= 6.63 \times 10^{-34} \times 3.00 \times 10^{8} / 2.3 \times 10^{-14}$ ✔

$\lambda = 8.6 - 8.7 \times 10^{-12}$ (m) ✔ (8.6478×10^{-12} m)

Allow a CE in the second mark only if the energy corresponds to an energy gap including those to the ground state.

The allowed energy gaps for CE are:

2.29, 2.06, 1.76, 0.53, 0.30 all $\times 10^{-13}$

Note substitution rather than calculation gains mark.

The final mark must be as shown here and not from a CE above.

3

[9]