UNIVERSITI SAINS MALAYSIA

Final Examination
2015/2016 Academic Session

May/June 2016

JIF 416 – Nuclear and Radiation Physics
[Ilmu Fizik Nuklear dan Sinaran]

Time : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **SEVEN** printed pages before you begin the examination.

Answer **ALL** questions. You may answer **either** in Bahasa Malaysia or in English.

Read the instructions carefully before answering.

Each question carries 20 marks.

In the event of any discrepancies in the exam questions, the English version shall be used.

*Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*

*Jawab **SEMUA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

Baca arahan dengan teliti sebelum anda menjawab soalan.

Setiap soalan diperuntukkan 20 markah.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

Constants:

Speed of light $c = 3.0 \times 10^{8}$ m s^{-1}

Avogadro's number $N_A = 6.02 \times 10^{23}$ mol^{-1}

Planck constant $h = 6.63 \times 10^{-34}$ J s

Boltzmann constant $k = 1.38 \times 10^{-23}$ J K^{-1}

Permittivity of free space $\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}

Permeability of free space $\mu_o = 4\pi \times 10^{-7}$ H m^{-1}

Basic charge $e = 1.6 \times 10^{-19}$ C

Electron rest-mass $m_e = 9.1 \times 10^{-31}$ kg

Proton rest-mass $m_p = 1.6725 \times 10^{-27}$ kg $\equiv$ 1.0072766 u

Neutron rest-mass $m_n = 1.6748 \times 10^{-27}$ kg $\equiv$ 1.0086654 u

Bohr's radius $a = 5.3 \times 10^{-11}$ m

1 eV = 1.6×10^{-19} J

1 u $\equiv$ 931 MeV c^{-2}

1 barn = 10^{-28} m^2

1 fm = 10^{-15} m

1 Ci = 3.7×10^{10} s^{-1}

Period	Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
1	1 **H** 1.00																	2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.98	16 **S** 32.07	17 **Cl** 35.46	18 **Ar** 39.94
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.71	29 **Cu** 63.54	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.91	36 **Kr** 83.8
5	37 **Rb** 85.47	38 **Sr** 87.66	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (99)	44 **Ru** 101.1	45 **Rh** 102.91	46 **Pd** 106.4	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
6	55 **Cs** 132.91	56 **Ba** 137.34	57–71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.09	79 **Au** 197.0	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** (210)	85 **At** (210)	86 **Rn** 222
7	87 **Fr** (223)	88 **Ra** 226.05	89–103 **															

*Rare earths	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.35	63 **Eu** 152.0	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.92	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
**Actinides	89 **Ac** 227	90 **Th** 232.04	91 **Pa** 231	92 **U** 238.03	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (249)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (253)	101 **Md** (256)	102 **No** (254)	103 **Lw** (257)

1. (a) Rutherford proposed that positively-charged particles (i.e. protons) are concentrated at the centre of an atom in the nucleus. Describe how the uncharged neutrons were discovered to be inside the nucleus too.

Rutherford telah mencadangkan bahawa zarah-zarah bercas positif (iaitu, proton) terletak di dalam nukleus di pusat atom. Terangkan bagaimana neutron yang tidak bercas juga didapati berada di dalam nukleus.

(5 marks/*markah*)

(b) Calculate the average binding energy per nucleon for $^{56}_{26}\text{Fe}$. Explain why it is easier to split the uranium nucleus than the iron nucleus in a fission process.

Hitung purata tenaga ikatan senukleon bagi $^{56}_{26}\text{Fe}$. *Jelaskan pembelahan mengapa lebih mudah untuk memecahkan nukleus uranium berbanding nukleus besi dalam suatu proses.*

(8 marks/*markah*)

(c) Assuming that the mass of a nucleon is equal to the mass of a proton, estimate the density of a nucleus. Given R_o = 1.2 fm.

Dengan menganggap jisim satu nukleon sama dengan jisim satu proton, anggarkan ketumpatan satu nukleus. Diberikan R_o *= 1.2 fm.*

(7 marks/*markah*)

2. (a)

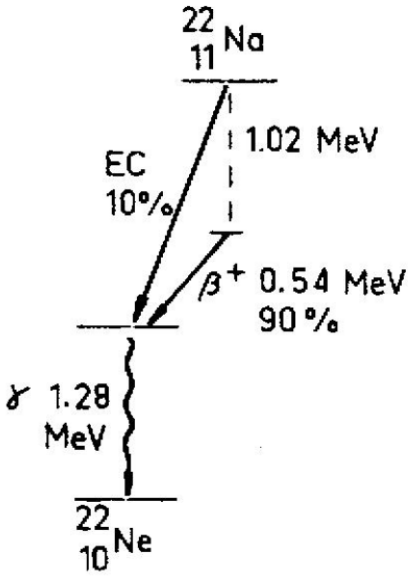

Figure 1/*Rajah 1*

Figure 1 shows the decay processes of Na-22 to Ne-22.
Rajah 1 menunjukkan proses-proses pereputan Na-22 kepada Ne-22.

(i) Describe the processes involved in the decay.
Perihalkan proses-proses yang terlibat dalam pereputan ini.

(ii) Write down the two possible equations for the decay processes. Note that a neutrino is also emitted.
Tuliskan dua persamaan yang berkemungkinan bagi proses-proses pereputan ini. Perhatikan bahawa neutrino juga dipancarkan.

(10 marks/*markah*)

(b) The half-life of Au-198 is 2.70 days.
Setengah hayat Au-198 ialah 2.70 hari.

(i) Determine the decay constant of the Au-198.
Tentukan pemalar pereputan Au-198 ini.

(ii) For a 1.00-g sample of Au-198, what is its activity?
Bagi satu 1.00 g sampel Au-198, berapakah aktivitinya?

(iii) Determine the activity of the sample after one week.
Tentukan aktiviti sampel itu selepas satu minggu.

(10 marks/*markah*)

3. (a) Define the *Q* value and the threshold energy of a nuclear reaction.
Takrifkan nilai Q dan tenaga ambang bagi suatu tindak balas nukleur.

(6 marks/*markah*)

(b) Deuterons are used to bombard Cu-63 in the following nuclear reaction:
Deuteron telah digunakan untuk menghentam Cu-63 dalam tindak balas nukleus berikut:

$$^{2}\mathrm{H} + {}^{63}\mathrm{Cu} \longrightarrow {}^{64}\mathrm{Zn} + \mathrm{n}$$

The mass of H-2 is 2.014102 u, the mass of Cu-63 is 62.929597 u and the mass of Zn-64 is 63.929142 u.
Jisim H-2 ialah 2.014102 u, jisim Cu-63 ialah 62.929597 u dan jisim Zn-64 ialah 63.929142 u.

(i) Compute the *Q* value for the nuclear reaction.
Hitung nilai Q tindak balas nukleur ini.

(ii) Assuming the kinetic energy of the incident deuterons be 12.00 MeV and the kinetic energy of the neutrons are observed to be 16.85 MeV. Determine the kinetic energy of Zn-64.
Andaikan tenaga kinetik deuteron tuju ialah 12.00 MeV dan tenaga kinetik neutron yang dicerap ialah 16.85 MeV. Tentukan tenaga kinetik Zn-64.

(14 marks/*markah*)

4. (a) Explain the meaning of the linear energy transfer (LET). What is straggling?
Jelaskan makna pemindahan tenaga linear (LET). Apakah yang dimaksudkan dengan 'straggling'?

(5 marks/*markah*)

(b) Describe the interactions of slow neutrons with matter. For each interaction, illustrate the involved mechanisms.
Perihalkan interaksi-interaksi neutron perlahan dengan jirim. Bagi setiap jenis interaksi, ilustrasikan mekanisme interaksi yang terlibat.

(9 marks/*markah*)

(c) Describe the biological effects of radiation exposure.
Perihalkan kesan biologi dedahan sinaran.

(6 marks/*markah*)

5. (a) Describe the construction and the mechanisms of a scintillation detector. What are the advantages and the disadvantages of a scintillation detector as compared to a simple ion chamber?
Perihalkan binaan dan mekanisme suatu pengesan sintilasi. Apakah kebaikan dan kelemahan suatu pengesan sintilasi berbanding suatu pengesan kebuk ion mudah.

(12 marks/*markah*)

(b) Describe the application of nuclear physics in the electrical power generation. Use suitable diagrams to illustrate your description.
Perihalkan penggunaan fizik nukleus dalam penjanaan kuasa elektrik. Gunakan gambar rajah - gambar rajah yang sesuai untuk menggambarkan pemerihalan anda.

(8 marks/*markah*)