



Final Examination
2017/2018 Academic Session

May/June 2018

JIF416 – Nuclear and Radiation Physics
[Ilmu Fizik Nuklear dan Sinaran]

Time : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **SIX** 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 **ENAM** 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 $c = 3.0 \times 10^8 \text{ m s}^{-1}$

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

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

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

Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$

Permeability of free space $\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$

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

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

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

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

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

1 eV = $1.6 \times 10^{-19} \text{ J}$

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

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

1 fm = 10^{-15} m

1 Ci = $3.7 \times 10^{10} \text{ s}^{-1}$

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). An old piece of wood is found to contain only 18 % of carbon-14 that a sample of fresh wood normally would have. How old is the piece of wood? (Half-life of carbon-14 is 5730 years).
Satu kayu lama didapati mengandungi hanya 18 % karbon-14 daripada sampel kayu segar. Berapa umur kayu lama itu? (Setengah hayat karbon-14 ialah 5730 tahun).
(4 marks/markah)
- (b). What is the activity of 1g of radium-226? (Half-life of radium-226 is 1600 years).
Berapakah aktiviti bagi 1g radium-226? (Setengah hayat radium-226 ialah 1600 tahun).
(6 marks/markah)
- (c). A building has been contaminated with a radioactive substance. The radioactive substance in the building is strontium-90 and its half-life is 29.1 years (Rest mass = 89.9077 u). Assume that the building initially contained 10.00 kg of this substance uniformly distributed throughout the building. How long will the building be unsafe if the safe level is defined as less than 10.0 decays/ min?
Sebuah bangunan kecil telah dicemari oleh bahan radioaktif. Bahan radioaktif di dalam bangunan ini ialah strontium-90 dan separuh hayatnya 29.1 tahun (Jisim rehat = 89.9077 u). Andaikan pada mulanya bangunan ini mengandungi 10.00 kg bahan ini yang ditaburkan secara seragam di seluruh bangunan ini. Berapa lama bangunan ini tidak selamat jika tahap selamat ditakrifkan kurang daripada 10.0 pereputan/ minit?
(10 marks/markah)

2. (a). Calculate the binding energy per nucleon of thorium-232 (^{232}Th) in

Hitung tenaga ikatan per nukleon bagi nukleus thorium-232 (^{232}Th) dalam

(i). MeV

MeV

(ii). Joules

Joule

(Given rest-mass of thorium-232 = 231.98864 u)

(Diberikan: jisim rehat thorium-232 = 231.98864 u)

(10 marks/markah)

- (b). A sealed box was found to contain an alloy composed of equal parts by the same weight of two metals A and B. These metals are radioactive, with half lives of 12 years and 18 years, respectively. When the container was opened it was found to contain 0.53 kg of metal A and 2.20 kg of metal B. Calculate the age of the alloy.

Satu kotak yang tertutup telah dijumpai dan mengandungi satu aloi yang terdiri daripada dua logam A dan B dengan mempunyai bahagian dan berat yang sama. Logam-logam ini adalah radioaktif, mempunyai setengah hayat 12 belas tahun dan 18 belas tahun masing-masing. Apabila kotak itu dibuka dan didapati mengandungi 0.53 kg logam A dan 2.20 kg logam B. Hitung umur aloi tersebut.

(10 marks/markah)

3. (a). State two characteristics of alpha emission.
Nyatakan dua ciri-ciri bagi pancaran alfa.
(4 marks/markah)
- (b). Describe the pair production in photon interaction. What is the minimum energy required for pair production?
Terangkan penghasilan pasangan dalam interaksi foton dan berapakah tenaga minimum yang diperlukan untuk penghasilan pasangan?
(8 marks/markah)
- (c). With the aid of diagram, describe the production of Bremsstrahlung X-ray and its spectrum.
Dengan bantuan gambar rajah, terangkan penghasilan sinar-x Bremsstrahlung dan spektrumnya.
(8 marks/markah)
4. (a). Describe the process of radioisotope production from a cyclotron.
Perihalkan proses penghasilan radioisotop daripada siklotron.
(10 marks/markah)
- (b). Discuss the operating principle of a nuclear reactor.
Bincangkan prinsip operasi reaktor nuklear.
(10 marks/markah)
5. (a). Discuss the operating principle of sodium iodide detector for radiation detection.
Bincangkan prinsip operasi pengesanan natrium iodida untuk pengesanan sinaran.
(10 marks/markah)
- (b). With the aid of a diagram, explain the gas ionisation curve.
Dengan bantuan gambar rajah, jelaskan prinsip lengkungan ionisasi gas.
(10 marks/markah)