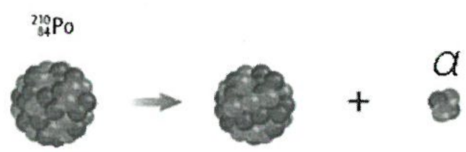
Student 8
Average 49.9 /100
Best 87/100

12thG Physics (2017– 18)

4thQ Final Exam

(May 30, 2018)

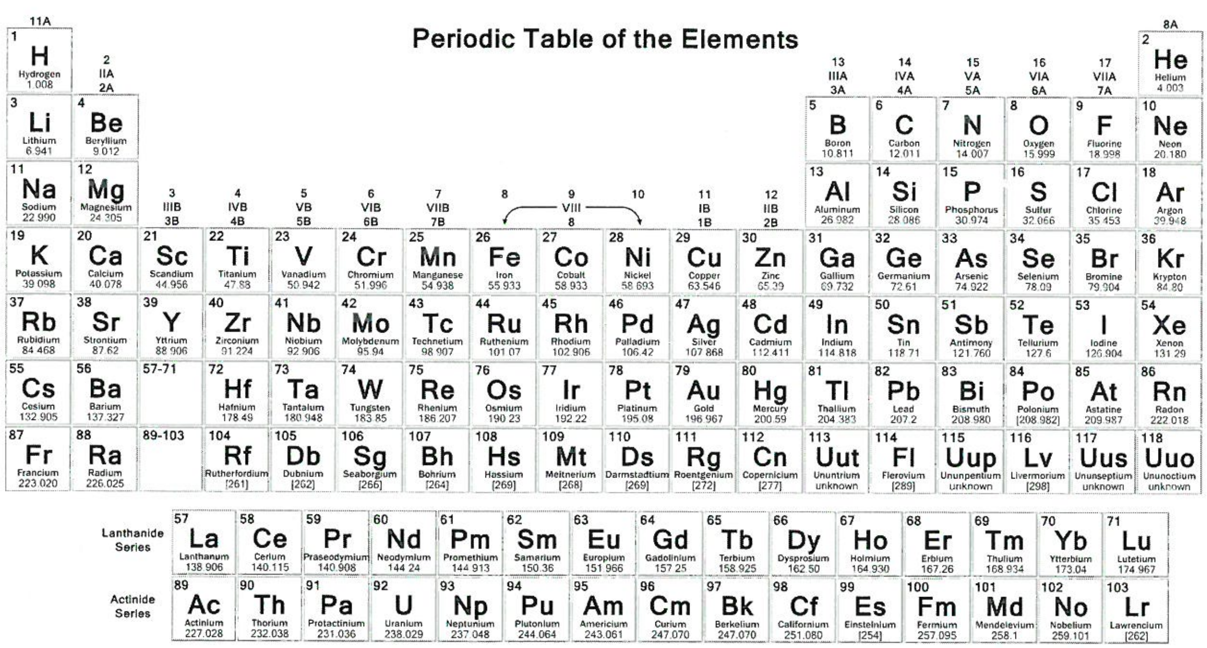
Class	No.	Name Solutions



In calculation problems, describe equations clearly and systematically enough to show how to solve the problems. **<u>If not enough, you won't get any point.</u>**

5points/Problem x 21Problems= 105Points
Max 100Points

Exam ／[Total 100 点]



5/30/2018 By Tohei Moritani

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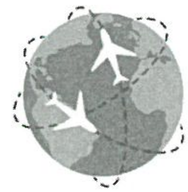
Physics Constants

The speed of light in vacuum	$c = 2.998 \times 10^8$ m/s
Gravitational acceleration rate	$g = 9.80$ m/s^2
Universal Gravitational Constant	$G = 6.674 \times 10^{-11}$ N・m^2/kg^2
Radius of the Earth	$R_E = 6.371 \times 10^6$ m
Mass of the Earth	$M_E = 5.972 \times 10^{24}$ kg
Mass of the Sun	$M_S = 1.9884 \times 10^{30}$ kg
Radius of the Mars	$R_M = 3.39 \times 10^6$ m
Mass of Mars	$M_M = 6.43 \times 10^{23}$ kg
Angular speed of Earth's Rotation	$\omega = 7.292 \times 10^{-5}$ rad/s
Volume of a sphere	$V = \frac{4}{3}\pi r^3$
Pi	$\pi = 3.1416$
Avogadro's Number	$N_A = 6.022 \times 10^{23}$ mol^{-1}
Universal Gas Constant	$R = 8.314$ J/(mol・K)
Boltzmann Constant	$k = 1.381 \times 10^{-23}$ J/K
Coulomb's Law constant	$k = 8.988 \times 10^9$ N・m^2/C^2
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N・m^2)
Elementary Charge	$e = 1.602 \times 10^{-19}$ C
Electron mass	$m_e = 9.109 \times 10^{-31}$ kg
Proton mass	$m_p = 1.673 \times 10^{-27}$ kg
Neutron Mass	$m_n = 1.675 \times 10^{-27}$ kg
calorie	1 cal = 4.186 J
The constant of the Wien's Displacement Law	5.88×10^{10} s^{-1}・K^{-1}
Planck's Constant	$h = 6.626 \times 10^{-34}$ J s
The constant in the Compton Shift	$h/m_e c = 2.43 \times 10^{-12}$ m
Rydberg Constant	$R = 1.097 \times 10^7$ m^{-1}
Atomic Mass Unit and Energy	1 u = 931.5 MeV/c^2

Atomic Number (Z)	Element	Symbol	Mass Number (A)	Atomic Mass*	Abundance (%) or Decay Mode† (if radioactive)	Half-Life (if radioactive)
0	(Neutron)	n	1	1.008665	β^-	10.6 min
1	Hydrogen	H	1	1.007825	99.985	
	Deuterium	D	2	2.014102	0.015	
	Tritium	T	3	3.016049	β^-	12.33 y
2	Helium	He	3	3.016029	0.00014	
			4	4.002603	≈100	
81	Thallium	Tl	205	204.97441	70.5	
			210	209.990069	β^-	1.3 min
82	Lead	Pb	204	203.973044	β^-, 1.48	1.4×10^{17} y
			206	205.97446	24.1	
			207	206.97589	22.1	
			208	207.97664	52.3	
			210	209.98418	α, β^-, γ	22.3 y
			211	210.98874	β^-, γ	36.1 min
			212	211.99188	β^-, γ	10.64 h
			214	213.99980	β^-, γ	26.8 min
83	Bismuth	Bi	209	208.98039	100	
			211	210.98726	α, β^-, γ	2.15 min
			212	211.991272	α	60.55 min
84	Polonium	Po	210	209.98286	α, γ	138.38 d
			212	211.988852	α	0.299 μs
			214	213.99519	α, γ	164 μs
86	Radon	Rn	222	222.017574	α, β	3.8235 d
87	Francium	Fr	223	223.019734	α, β^-, γ	21.8 min
88	Radium	Ra	226	226.025406	α, γ	1.60×10^3 y
			228	228.031069	β^-	5.76 y
89	Actinium	Ac	227	227.027751	α, β^-, γ	21.773 y
90	Thorium	Th	228	228.02873	α, γ	1.9131 y
			231	231.036297	α, β^-	25.52 h
			232	232.038054	100; α, γ	1.41×10^{10} y
			234	234.043596	β^-	24.10 d
91	Protactium	Pa	234	234.043302	β^-	6.70 h
92	Uranium	U	232	232.03714	α, γ	72 y
			233	233.039629	α, γ	1.592×10^5 y
			235	235.043925	0.72; α, γ	7.038×10^8 y

(1) An airplane flies level to the ground toward the north pole. Is the induced emf from wing tip to wing tip when the plane is at the equator greater than, less than, or equal to the wing-tip-to-wing-tip emf when it is at the latitude of New York?

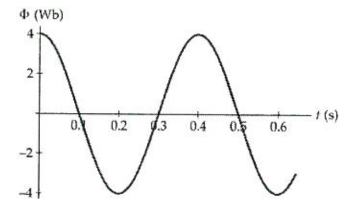


At the equator, the field is horizontal.
At the latitude of NY, the vertical component is present.

(1) Answer
Less than

(50%)

(2) The figure at the right shows the magnetic flux through a coil as a function of time. At what times shown do the induced emf have the greatest magnitude?

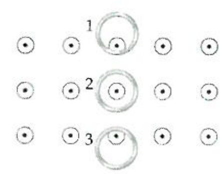


$$V = N\left|\frac{\Delta \Phi}{\Delta t}\right|$$

(2) Answer
0.1 s ; 0.3 s , 0.5 s

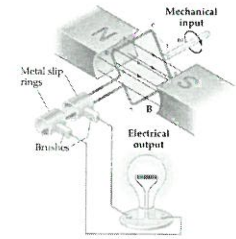
(18%)

(3) A metal ring is dropped into a localized region of constant magnetic field, as indicated in the figure. The magnetic field is zero above and below the region. For each of the three indicated locations (1, 2 and 3), is the induced current clockwise (CW), counterclockwise (CCW), or zero (Z)?



(3) Answer
1: CW 2: Z 3: CCW

(74%)



(4) The maximum induced emf in a generator rotating at 210 rpm is 45V. How fast must the rotor of the generator rotates if it is to generate a maximum induced emf of 55 V?
(Equations)

$$V_{max} = N\omega AB = NAB \times 210 = 45$$

$$\rightarrow NAB = 0.213$$

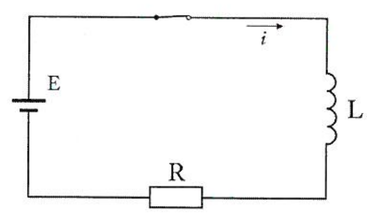
$$\omega' = \frac{55}{NAB} = \frac{55}{0.213} = 257 \rightarrow 260$$

(4) Answer

260 rpm

(63%)

(5) Find the induced emf when the current in a 45.0-mH inductor increases from 0 to 515 mA in 16.5 ms.
(Equations)



$$V = L\left|\frac{\Delta I}{\Delta t}\right|$$

$$= 45.0\times10^{-3}\times\left|\frac{515\times10^{-3}}{16.5\times10^{-3}}\right|$$

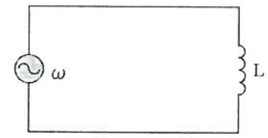
$$= 1.4045 \rightarrow 1.40\ (V)$$

(5) Answer

1.40 V

(51%)

(6-a) An inductor has a reactance of 56.5 Ω at 75.0 Hz. What is its reactance at 60.0 Hz?
(Equations)



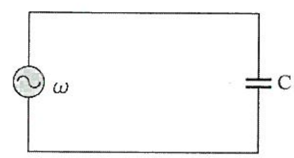
$$X = 2\pi f L$$

$$L = \frac{X}{2\pi f} = \frac{56.5}{2\pi \times 75}$$

$$X' = 2\pi f' L$$

$$= 2\pi \times 60.0 \times \frac{56.5}{2\pi \times 75} = 45.20 \rightarrow 45.2$$

(6-b) A 105-μF capacitor is connected to an AC generator with an rms voltage of 20.0 V and a frequency of 100.0 Hz. What is the rms current in this circuit?
(Equations)



$$I = \frac{V}{X} = \frac{1}{\frac{1}{2\pi f C}}$$

$$= 20.0 \times 2\pi \times 100 \times 105 \times 10^{-6}$$

$$= 1.320 \rightarrow 1.32 (A)$$

(6-a) Answer
45.2 Ω
(6-b) Answer
1.32 A

(69%)

(7-a) How fast does a 125-m spaceship move relative to an observer who measures the ship's length to be 65.0 m? Express your answer as a fraction of the speed of light, c.
(Equations)

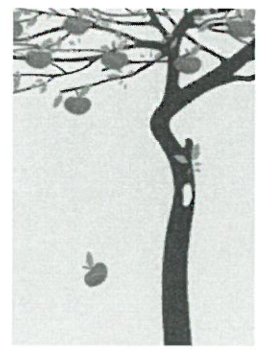
$$L = L_0 \sqrt{1 - \left(\frac{v_0}{c}\right)^2}$$

$$\rightarrow \quad v = c\sqrt{1 - \left(\frac{L}{L_0}\right)^2}$$

$$= c\sqrt{1 - \left(\frac{65}{125}\right)^2}$$

$$= 0.8542c \longrightarrow 0.854c$$

(7-b) An apple falls from a tree, landing on the ground 3.7 m below. How long is the apple in the air, as measured by an observer moving toward Earth with a speed of 0.89c?
(Equations)



$$y = \frac{1}{2} g \Delta t_0^2$$

$$\Delta t_0 = \sqrt{\frac{2y}{g}} = \sqrt{\frac{2 \times 3.7}{9.80}}$$

$$= 0.869$$

$$\Delta t = \frac{\Delta t_0}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$$= \frac{0.869}{\sqrt{1 - (0.89)^2}}$$

$$= 1.906 \longrightarrow 1.9 \text{ (s)}$$

(7-a) Answer	0.854 c
(7-b) Answer	1.9 s

(58%)

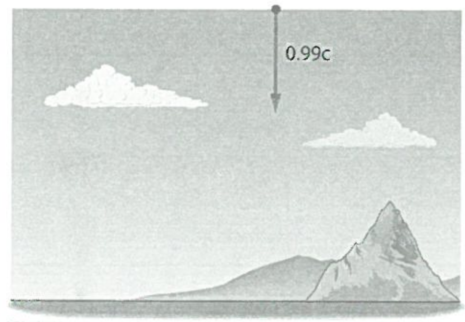
5/30/2018 By Tohei Moritani

(8,9) An elementary particle called a pi meson (or pion for short) has an average lifetime of 2.6×10^{-8} s when at rest. If a pion moves with a speed of 0.99c relative to Earth, answer the following questions.

(8) Find the average lifetime of the pion as measured by an observer on Earth.

(9) Find the average distance traveled by the pion as measured by the same observer.

(Equations)



(8) $\Delta t = \dfrac{\Delta t_0}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$

$= \dfrac{2.6 \times 10^{-8}}{\sqrt{1-0.99^2}}$

$= \dfrac{2.6 \times 10^{-8}}{0.1411} = 18.43 \times 10^{-8}$

$\rightarrow 1.8 \times 10^{-7}$ (s)

(9) $d = v \Delta t$

$= 0.99 \times 3.00 \times 10^{8} \times 1.843 \times 10^{-7}$

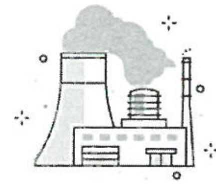
$= 54.7$

$\rightarrow 55$ (m)

(8) Answer 1.8×10^{-7} s (76%)

(9) Answer 55 m (25%)

(10) A nuclear power plant produces an average of 1.0 x 10^3 MW of power a year of operation. Find the corresponding change in mass of reactor fuel, assuming all of the energy released by the fuel can be converted directly to electrical energy. (In a practical reactor, only a relatively small fraction of the energy can be converted to electricity)



(Equations)

$\Delta E = 1.0 \times 10^3 \times 10^6$ J/y

$\Delta E = \Delta m c^2$

$\Delta m = \frac{\Delta E}{c^2}$

$= \frac{1.0 \times 10^9}{(3.00 \times 10^8)^2}$

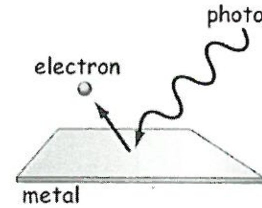
$= 0.111 \times 10^{-8}$

$\rightarrow 1.11 \times 10^{-9}$ kg $(= 1.11 \times 10^{-6}$ g $\rightarrow 1.1\ \mu$g$)$

(10) Answer 1.1 μg /y (26%)

$(3.5 \times 10^{-16}$ g/s$)$

(11,12) The work function of a particular metal is 2.00 eV. The metal is illuminated with light of 550 nm.
(11) Find the maximum energy (eV) of the emitted electrons.
(12) Find the maximum speed of the electrons.
(Equations)



(11) $K = E - W_0$

$= hf\,[J] - W_0$

$= \frac{hf}{e}\,[eV] - W_0 = \frac{h \times \frac{c}{\lambda}}{e} - W_0$

$= \frac{hc}{e\lambda} - W_0$

$= \frac{6.626 \times 10^{-34} \times 2.998 \times 10^{8}}{1.602 \times 10^{-19} \times 550 \times 10^{-9}} - 2.00$

$= 2.2545 - 2.00$

$= 0.2545\ (eV) \longrightarrow 0.25\ eV$

(12)
$K = 0.2545\ eV = 0.2545 \times 1.602 \times 10^{-19}\ (J)$

$v = \sqrt{\frac{2K}{m}}$

$= \sqrt{\frac{2 \times 0.2545 \times 1.602 \times 10^{-19}}{9.109 \times 10^{-31}}}$

$= \sqrt{8.952 \times 10^{-2+31-19}}$

$= 2.992 \times 10^{5}$

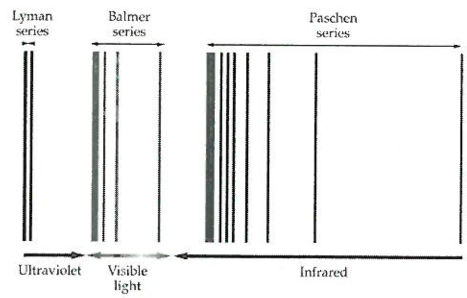
$\longrightarrow 2.99 \times 10^{5}\ (m/s)$

(11) Answer $0.25\ eV$ (29%)

(12) Answer $2.99 \times 10^{5}\ m/s$ (23%)

(13,14) The figure shows the spectral lines in the spectrum of hydrogen atom.
(13) Calculate the longest wavelength (nm) of the Paschen series

(14) Calculate the ionization energy (eV) of hydrogen when it is in the ground-state, using the formula including the Rydberg constant. (Equations)



(13)

$$\frac{1}{\lambda} = R\left(\frac{1}{n'^2} - \frac{1}{n^2}\right)$$

$$= 1.097\times10^7\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$

$$\lambda = 18.752\times10^{-7}\ m \longrightarrow 1875\ nm$$

(14)

$$\frac{1}{\lambda} = R\left(\frac{1}{n'^2} - \frac{1}{n^2}\right)$$

$$= R\left(\frac{1}{1^2} - 0\right) = 1.097\times10^7$$

$$E = \frac{hf}{e} = \frac{hc}{e\lambda}$$

$$= \frac{1.097\times10^7 \times 6.626\times10^{-34} \times 2.998\times10^8}{1.602\times10^{-19}}$$

$$= 13.603\times10^{7+8+19-34}$$

$$= 13.603 \rightarrow 13.60$$

(13) Answer 1875 nm (21%)

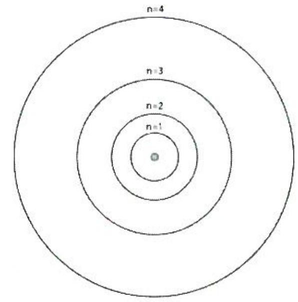
(14) Answer 13.60 eV (13%)

(15,16) The figure shows the first four Bohr orbits of hydrogen atom. Based on the Bohr's model, the radius of the smallest (n = 1) is calculated as 5.29×10^{-11} m.

(15) Find the radius of the n = 4 orbit.

(16) Find the de Broglie wavelength of an electron in the n = 4 state of the hydrogen atom.

(Equations)



(15) $r_4 = n^2 r_1$

$= 4^2 \times 5.29 \times 10^{-11} = 84.640 \times 10^{-11} \rightarrow 8.46 \times 10^{-10}$ m

(16) $d = 2\pi r_4 = 2\pi \times 84.640 \times 10^{-10}$

$\lambda_4 = \frac{d}{4} = \frac{2\pi}{4} \times 84.640 \times 10^{-10}$

$= 133 \times 10^{-11}$

$\rightarrow 1.33 \times 10^{-9}$ (m)

(15) Answer	
8.46×10^{-10} m	(39%)

(16) Answer	
1.33×10^{-9} m	(25%)

(17,18) Complete the following nuclear-decay equations:

(17-a) $^{238}_{92}U \rightarrow$ $^{234}_{90}Th$ $+$ $^{4}_{2}He$

(17-b) $^{40}_{19}K \rightarrow$ $^{40}_{20}Ca$ $+$ $^{0}_{-1}e$

(18-c) $^{236}_{92}U \rightarrow$ $^{131}_{53}I$ $+$ 3 $(^{1}_{0}n)$ $+$ $^{102}_{39}Y$

(18-d) $^{47}_{21}Sc^* \rightarrow$ $^{47}_{21}Sc$ $+$ γ

(18-e) $^{22}_{9}F$ $\rightarrow$ $^{0}_{-1}e$ $+$ $^{22}_{10}Ne$

(17-a) Answer

Complete the equation

(17-b) Answer

Complete the equation

(98%)

(18-c) Answer

Complete the equation

(18-d) Answer

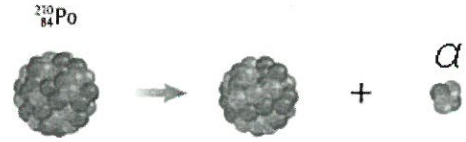
Complete the equation

(18-e) Answer

Complete the equation

(58%)

(19) The nucleus $^{212}_{84}Po$ is observed to decay by emitting an α particle.
(19-a) Write out the decay process.
(19-b) Determine the energy released in the reaction.
(Equations)



$m_i = 211.988852$

$m_f = 207.97664 + 4.002603$

$= 211.979243$

$E = (m_i - m_f)c^2$

$= 0.009609\ u \times \frac{931.5\ MeV/c^2}{1\ u}$

$= 8.9508\ (MeV)$

$\rightarrow 8.95\ MeV$

(19-a) Answer

$^{212}_{84}Po \rightarrow ^{208}_{82}Pb + ^{4}_{2}He$

(29%)

(19-b) Answer

8.95 MeV

(20) A radioactive sample is placed in a closed container. Three days later only one-quarter of the sample is still radioactive. What is the half-life of this sample?
(Equations)

$\frac{N}{N_0} = e^{-\lambda t} = \frac{1}{4}$

$\ln\frac{1}{4} = -\lambda t \qquad \lambda = \frac{\ln 2}{T}$

$-\ln 4 = -\frac{\ln 2}{T} \times 3$

$T = \frac{\ln 2}{\ln 4} \times 3 = 1.5\ (days)$

(20) Answer

1.5 days

(40%)

You have one more question.

(21) Did you study 12^{th} grade physics seriously and enjoy it?

(21) Answer
Circle your answer.
Yes No Neutral

(100 %)

I am very happy to meet you! Tohei

Please tell me which department and course you enter when it is decided officially.

Opinions	Your name: