UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 117.3
Physics for the Life Sciences

FINAL EXAMINATION

April 18, 2015 Time: 3 hours

NAME: Solutions STUDENT NO.: ____________
(Last) **Please Print** (Given)

LECTURE SECTION (please check):

- ❑ 01 Dr. Y. Yao
- ❑ 02 Mr. B. Zulkoskey
- ❑ C16 Dr. A. Farahani

INSTRUCTIONS:

1. This is a closed book examination.
2. The test package includes a test paper (this document), a formula sheet, and an OMR sheet. The test paper consists of 11 pages, including this cover page. **It is the responsibility of the student to check that the test paper is complete**.
3. Only a basic scientific calculator (e.g. Texas Instruments TI-30X series, Hewlett-Packard HP 10s or 30S) may be used. Graphing or programmable calculators, or calculators with communication capability, are **not** allowed.
4. Enter your name and student number on the cover of the test paper and check the appropriate box for your lecture section. Also enter your student number in the top right-hand corner of each page of the test paper.
5. Enter your name and **NSID** on the OMR sheet.
6. The test paper, the formula sheet and the OMR sheet must all be submitted.
7. None of the test materials will be returned.

ONLY THE FIVE PART B QUESTIONS THAT YOU INDICATE WILL BE MARKED

PLEASE INDICATE WHICH FIVE PART B QUESTIONS ARE TO BE MARKED

QUESTION NUMBER	TO BE MARKED	MAXIMUM MARKS	MARKS OBTAINED
A1-25	☑	25	
B1	❑	10	
B2	❑	10	
B3	❑	10	
B4	❑	10	
B5	❑	10	
B6	❑	10	
TOTAL		75	

continued on page 2...

PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

$\frac{F}{A} = Y\frac{\Delta L}{L_0} \Rightarrow \Delta L = L_0\left(\frac{F}{A}\right)\cdot\frac{1}{Y}$; $\left(\frac{F}{A}\right)_2 = \left(\frac{F}{A}\right)_1$; $Y_2 = Y_1$

D

A1. Consider two bars made of copper. The length of bar 2 is twice the length of bar 1. i.e. $L_{02} = 2L_{01}$. If the same tensile stress is exerted on each bar, what is the change in length of bar 2 compared to the change in length of bar 1?

$\Delta L_{02} = L_{02}\left(\frac{F}{A}\right)\cdot\frac{1}{Y}$

$\Delta L_{02} = 2\left(L_{01}\left(\frac{F}{A}\right)\cdot\frac{1}{Y}\right) = 2\Delta L_{01}$

(A) $\Delta L_{02} = ¼\,\Delta L_{01}$ (B) $\Delta L_{02} = ½\,\Delta L_{01}$ (C) $\Delta L_{02} = \Delta L_{01}$ (D) $\Delta L_{02} = 2\Delta L_{01}$ (E) $\Delta L_{02} = 4\Delta L_{01}$

D

A2. Consider two identical containers that are open to the atmosphere. One container is filled with a fluid of density ρ_1. The other container is filled with a fluid of density ρ_2. $\rho_2 = 2\rho_1$. Which one of the following statements is correct regarding the gauge pressure at a depth h in each container?

$P_h = P_{atm} + \rho g h$; $P_{gauge_h} = P_h - P_{atm} = \rho g h$; $\rho_2 = 2\rho_1 \Rightarrow P_{gauge_2} = 2P_{gauge_1}$

(A) $P_2 < ½\,P_1$ (B) $P_2 = ½\,P_1$ C) $P_2 = P_1$ (D) $P_2 = 2P_1$ (E) $P_2 > 2P_1$

C

A3. A hydraulic lift consists of two cylinders connected by an incompressible fluid. Each cylinder contains a piston, one of radius R and the other of radius 0.2 R. If a car weighing 15000 N sits on a platform on top of the larger piston, what force must be applied to the smaller piston in order to lift the car?

Pascal's Principle, $\Delta P_2 = \Delta P_1 \Rightarrow F_2/A_2 = F_1/A_1 \Rightarrow F_1 = \left(\frac{A_1}{A_2}\right)\cdot F_2$

(A) 1500 N (B) 3000 N (C) 600 N (D) 6000 N (E) 15000 N

$F_1 = \left(\pi r_1^2/\pi r_2^2\right)F_2 = \left((0.2R)^2/R^2\right)\cdot 15000\,N = (0.04)(15000\,N)$

$F_1 = 600\,N$

E

A4. When ice floats in water, about 10% of the ice's volume is above the surface of the water. If we float some ice in a glass of water, what will happen to the water level as the ice melts?

(A) The water level will rise an amount corresponding to 10% of the volume of ice that has melted.
(B) The water level will rise an amount corresponding to more than 10% of the volume of ice that has melted.
(C) The water level will rise an amount corresponding to less than 10% of the volume of ice that has melted.
(D) The water level will become lower.
(E) The water level will remain unchanged.

Archimedes' Principle.
Since the weight of the ice cube corresponds to the weight of the displaced water, as the ice cube melts it "replaces" the displaced water and the level is unchanged.

E

A5. A block on a horizontal frictionless surface is connected to an ideal spring. When the spring is compressed a distance x and the block is released, the maximum kinetic energy of the block is KE_1. If the spring is compressed a distance $2x$ and the block is released, the maximum kinetic energy of the block is…

$KE_{max} = PE_{max} = \frac{1}{2}kx_{max}^2 \therefore KE_{max} \propto x_{max}^2$

(A) $KE_2 = ¼\,KE_1$. (B) $KE_2 = ½\,KE_1$. (C) $KE_2 = KE_1$. (D) $KE_2 = 2\,KE_1$. (E) $KE_2 = 4\,KE_1$.

D

A6. Two loudspeakers are producing in-phase sound waves of the same wavelength, λ. In which one of the following situations will constructive interference occur at the position of the observer?

(A) The observer is a distance of λ from one speaker and a distance of ½ λ from the other speaker.
(B) The observer is a distance of 2λ from one speaker and a distance of ½ λ from the other speaker.
(C) The observer is a distance of 3λ from one speaker and a distance of 1½ λ from the other speaker.
(D) The observer is a distance of ½ λ from one speaker and a distance of ½ λ from the other speaker.
(E) The observer is a distance of 2λ from one speaker and a distance of 2½ λ from the other speaker.

Constructive interference $\Rightarrow r_2 - r_1 = n\lambda$ where $n = 0, \pm1, \pm2, \ldots$

B

A7. The wave speed in a guitar string is v. If a second guitar string has double the tension and half the mass per unit length, what is the wave speed in the second string?

$v = \sqrt{F/\mu}$; $v_2 = \sqrt{\frac{2F}{\frac{1}{2}\mu}}$

(A) v (B) $2\,v$ (C) $\sqrt{2}\;v$ (D) $4\,v$ (E) $½\,v$

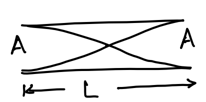
$v_2 = \sqrt{\frac{4F}{\mu}}$

$v_2 = 2v$

C

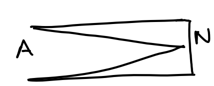
A8. A tube open at both ends has a fundamental resonant frequency of f. If you close one end of the tube, the fundamental resonant frequency becomes…

(A) f (B) $2f$ (C) $½f$ (D) $\frac{3}{2}f$ (E) $4f$



$L = \frac{1}{2}\lambda_0$ $f_0 = \frac{v}{2L}$

$\lambda_0 = 2L$



$L = \frac{1}{4}\lambda_c \Rightarrow \lambda_c = 4L$

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$f_c = \frac{v}{4L} = \frac{1}{2}\left(\frac{v}{2L}\right) = \frac{1}{2}f_0$

Student No.: ______________________

A9. When white light disperses as it passes through a prism, the deviation angle between the incident and outgoing light rays increases from red to yellow to green to blue to violet. For which of the following colours is the speed of the light in the prism the lowest?

A

Deviation angle increases with increasing n.

(A) Violet (B) Green (C) Yellow (D) Red
(E) The speed of light in the prism is the same for all colours.

$\therefore n_v > n_r$ and $n = \frac{c}{v}$

$\therefore v = c/n \Rightarrow v_v < v_r$

A10. Which one of the following statements is true regarding electromagnetic waves traveling through a vacuum?

D

(A) All waves have the same wavelength.
(B) All waves have the same frequency.
(C) The speeds of the waves depend on their frequencies.
(D) The electric and magnetic fields associated with the waves are perpendicular to each other.
(E) The electric and magnetic fields associated with the waves are parallel to the direction of wave propagation.

A11. A projector lens is needed to form an image on a screen such that the image is 10 times the size of the object. The screen is located 8.0 m from the lens. What is the required focal length of the lens?

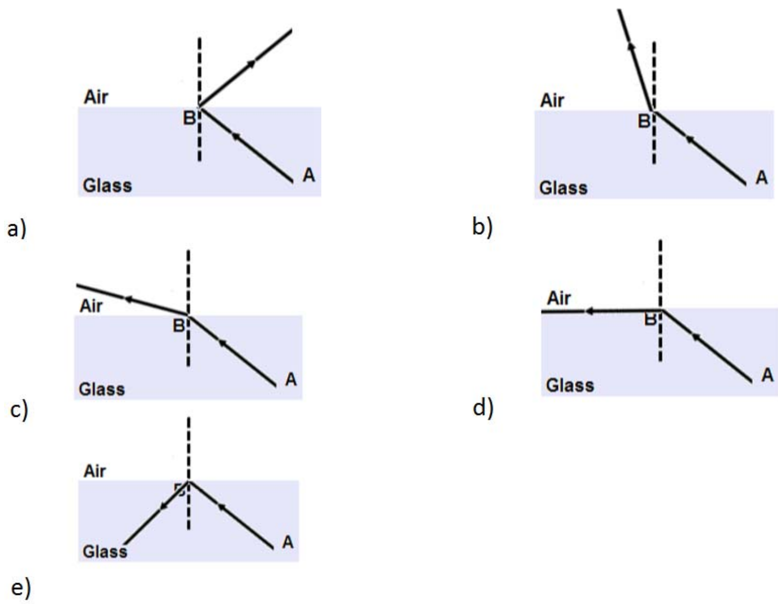
C

$|M| = |q/p| = 10 \Rightarrow q = 10p \Rightarrow p = 0.8\,\text{m}$ $f = \left(\frac{1}{p} + \frac{1}{q}\right)^{-1} = 0.73\,\text{m}$

(A) 0.32 m (B) 0.54 m (C) 0.73 m (D) 0.89 m (E) 1.25 m

A12. A light ray AB passes from glass into air at the critical angle. Which one of the following diagrams correctly represents the refracted ray?

D



A13. A diffraction grating is illuminated with yellow light at normal incidence. The pattern seen on a screen consists of three yellow spots, one at zero degrees (straight through) and one each at ±45°. You now add red light of equal intensity, also illuminating the grating at normal incidence. The new pattern on the screen consists of

D

$m\lambda = d\sin\theta \Rightarrow \theta \uparrow$ as $\lambda \uparrow$ for same m.

(A) red spots at 0° and ±45°. (B) yellow spots at 0° and ±45°.
(C) orange spots at 0° and ±45°.
(D) an orange spot at 0°, yellow spots at ±45°, and red spots at > 45°.
(E) an orange spot at 0°, yellow spots at ±45°, and red spots at < 45°.

$\lambda_{red} > \lambda_{yellow}$

$\Rightarrow \theta_{1\,red} > \theta_{1\,yellow}$

A14. Light of wavelength λ passes through a single slit of width a and forms a diffraction pattern on a screen. If the light source is replaced with one that emits light of wavelength 2λ, the original diffraction pattern is reproduced if the slit width is changed to

C

$\sin\theta_{dark} = m\frac{\lambda}{a}$

(A) ¼ a. (B) ½ a. (C) $2a$. (D) $4a$.
(E) No change in slit width is necessary.

Since $\lambda_2 = 2\lambda_1$, $a_2 = 2a_1$ for θ_{dark} to remain the same.

continued on page 4...

A15. For a given lens diameter, which colour of light gives the best resolution in a microscope? Recall that the wavelengths of visible light range from 400 nm for violet to 700 nm for red.

D

(A) Red (B) Yellow (C) Green (D) Violet $\theta_{min} = 1.22 \frac{\lambda}{D}$
(E) All colours give the same resolution.

A16. A farsighted person's vision will be corrected by a lens that

B

(A) takes an object at the person's near point and forms an image at 25 cm.
(B) takes an object at 25 cm and forms an image at the person's near point.
(C) takes an object at 25 cm and forms an image at infinity.
(D) takes an object at infinity and forms an image at 25 cm.
(E) takes an object at infinity and forms an image at the person's near point.

Need to correct the person's near vision. The person's uncorrected near point is > 25 cm.

A17. Consider a bimetallic strip: two different metals securely bonded together. The metals comprising the two sides of the strip are of equal length at room temperature. The metal on the left side of the strip has a greater coefficient of expansion than the metal on the right side of the strip. Which one of the following statements **best** describes the result when the strip is cooled to a temperature below room temperature? material with larger α will contract more.

C

(A) The strip bends to the right because the left side of the strip expands more than the right side.
(B) The strip bends to the right because the right side of the strip contracts more than the left side.
(C) The strip bends to the left because the left side of the strip contracts more than the right side.
(D) The strip bends to the left because the right side of the strip expands more than the left side.
(E) The strip remains perfectly straight.

A18. Consider an ideal gas confined in a container of fixed volume. The absolute pressure of the gas is P_1. Which one of the following statements **best** describes the effect on the absolute pressure of the gas when the temperature of the gas in the container is increased from 20°C to 40°C? i.e. How is the new pressure, P_2, related to the original pressure, P_1? $PV = nRT \Rightarrow P \propto T$ for T in K.

D

(A) $P_2 < \frac{1}{2} P_1$ (B) $P_2 = \frac{1}{2} P_1$ (C) $P_2 = P_1$ (D) $P_1 < P_2 < 2P_1$ (E) $P_2 = 2P_1$

20°C to 40°C is less than a doubling of T in K

A19. If the absolute temperature of an object is doubled, by what factor does the rate at which it emits thermal radiation change? $P_{emitted} = \sigma \epsilon A T^4$

D

(A) 2 (B) 4 (C) *8* (D) 16 (E) 32

A20. Light of a certain frequency and intensity, shining on a metal surface, causes electrons to be ejected. Which one of the following statements correctly describes the result if light of higher frequency, but equal intensity, now shines on the same metal surface?

C

$f \uparrow \Rightarrow KE_{max} \uparrow$; same intensity $\Rightarrow$ same electron emission rate

(A) Electrons are no longer ejected.
(B) Both the maximum energy and the rate of emission of electrons increase.
(C) The maximum energy of the ejected electrons increases but the rate of emission remains the same.
(D) The maximum energy of the ejected electrons remains the same but the rate of emission increases.
(E) Electrons are still ejected at the same rate and with the same maximum energy.

A21. The half-life of a radioactive element which has only 1/32 of its original activity after 60 days is

C

(A) 2 days. (B) 6 days. (C) 12 days. (D) 16 days. (E) 30 days.

$\frac{1}{32} = \left(\frac{1}{2}\right)^5$ = 5 half-lives = 60 days
$\therefore T_{1/2} = 12$ days

A22. In the reaction below, what is particle *X*?

D

$$^{9}_{4}\text{Be} + ^{4}_{2}\text{He} \rightarrow ^{12}_{6}\text{C} + X$$

(A) an electron (B) a proton (C) an alpha particle (D) a neutron (E) a photon

$X \Rightarrow ^{1}_{0}X \Rightarrow$ neutron

continued on page 5…

A23. Which phenomenon provided evidence that the hydrogen atom has discrete energy levels?

D

(A) Natural radioactive decay
(B) Alpha particle scattering
(C) Photoelectric emission
(D) Discrete line emission spectra
(E) Compton effect

A24. An alpha particle consists of two protons and two neutrons and has a radius of r_α. Let the radius of the nucleus of ${}^{32}_{15}\mathrm{P}$ be denoted r_P. Which one of the following is the correct expression for the relationship between r_P and r_α?

A

$r \propto A^{1/3}$ $\quad A_P/A_\alpha = 32/4 = 8 \quad \therefore r_P/r_\alpha = \sqrt[3]{8}$

(A) $r_P = 2\, r_\alpha$ (B) $r_P = 4\, r_\alpha$ (C) $r_P = 7.5\, r_\alpha$ (D) $r_P = 8\, r_\alpha$ (E) $r_P = 16\, r_\alpha$

$r_P = 2r_\alpha$

A25. Which one of the following statements concerning the strong nuclear force is **<u>TRUE</u>**?

D

(A) The strong nuclear force is attractive between neutrons and repulsive between protons.
(B) The strong nuclear force occurs only between neutrons, it does not act between a neutron and a proton or between two protons.
(C) All of the nucleons in a large nucleus feel the strong nuclear force due to all the other nucleons.
(D) The strong nuclear force between any two nucleons (proton-proton, proton-neutron, or neutron-neutron) is attractive.
(E) The strength of the strong nuclear force between two neutrons is approximately the same magnitude as the gravitational force between two neutrons.

<u>PART B</u>

ANSWER <u>FIVE</u> PART B QUESTIONS AND INDICATE YOUR CHOICES ON THE COVER PAGE.

IN EACH OF THE PART B QUESTIONS ON THE FOLLOWING PAGES:

- **GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.**
- **THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.**
- **<u>SHOW AND EXPLAIN YOUR WORK</u> – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.**
- **EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.**
- **USE THE BACK OF THE PREVIOUS PAGE FOR YOUR ROUGH WORK.**

continued on page 6…

B1. A circular-cross-section blood vessel of length L has a diameter of 2.00 cm. Blood flows through the blood vessel with a speed of 40.5 cm/s, maintained by a pressure difference of 32.5 Pa. The density of the blood at body temperature is 1.05×10^3 kg/m^3, and its coefficient of viscosity is 2.73×10^{-3} N·s/m^2.

(a) Calculate the volume flow rate of the blood. (3 marks)

$\boxed{1.27 \times 10^{-4}\ m^3/s}$

$$Q = \frac{\Delta V}{\Delta t} = Av = \frac{\pi d^2}{4} \cdot v$$

$$Q = \pi \frac{(0.0200 m)^2}{4} \cdot 0.405\ m/s = 1.27 \times 10^{-4}\ m^3/s$$

(b) Calculate the mass flow rate of the blood. If you did not obtain an answer for (a), use a value of 1.30×10^{-4} m^3/s. (3 marks)

$\boxed{0.134\ kg/s}$

$$\frac{\Delta m}{\Delta t} = \rho A v = \rho \frac{\Delta V}{\Delta t}$$

$$\frac{\Delta m}{\Delta t} = (1.05 \times 10^3\ kg/m^3)(1.27 \times 10^{-4}\ m^3/s) = 0.134\ kg/s$$

(c) Calculate the length L of the blood vessel. (4 marks)

$\boxed{0.368\ m}$

Viscous flow ⇒ Poiseuille's Law :

$$\frac{\Delta V}{\Delta t} = \frac{\pi R^4 (P_1 - P_2)}{8 \eta L}$$

$$L = \frac{\pi R^4 (P_1 - P_2)}{8 \eta (\Delta V / \Delta t)} = \frac{\pi (0.0100 m)^4 (32.5\ Pa)}{8 (2.73 \times 10^{-3}\ Pa \cdot s)(1.27 \times 10^{-4}\ m^3/s)}$$

$$L = 0.368\ m$$

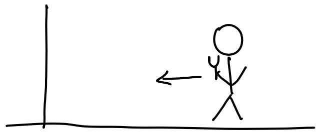
continued on page 7...

Student No.: ______________________

B2. A student holds a tuning fork that is oscillating at 912 Hz. She walks toward a wall at a constant speed of 2.63 m/s. The speed of sound is 343 m/s.

(a) Calculate the frequency of the sound waves striking (and reflecting from) the wall. (4 marks)

$\boxed{919\text{ Hz}}$



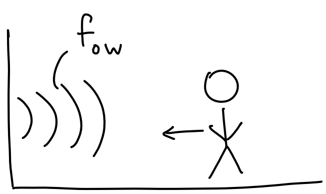
Tuning fork is moving source, wall is stationary observer.

$$f_{ow} = \left(\frac{v+v_o}{v-v_s}\right) f_s = \left(\frac{v}{v-v_s}\right) f_s$$

$$f_{ow} = \left(\frac{343\text{ m/s}}{343\text{m/s} - 2.63\text{m/s}}\right)(912\text{ Hz}) = 919\text{ Hz}$$

(b) Calculate the frequency of the sound waves that the student hears due to the echo from the wall. If you did not obtain an answer for (a), use a value of 918 Hz. (4 marks)

$\boxed{926\text{ Hz}}$



The student is a moving observer of the sound waves reflecting from the wall at frequency f_{ow}.

$$f_{os} = \left(\frac{v+v_o}{v}\right) f_{ow} = \left(\frac{343\text{m/s} + 2.63\text{ m/s}}{343\text{ m/s}}\right)(919\text{Hz}) = 926\text{ Hz}$$

(c) Calculate the beat frequency that the student hears between the tuning fork and its echo. If you did not obtain an answer for (b), use a value of 925 Hz. Express your answer to 2 significant figures. (2 marks)

$\boxed{14\text{ Hz}}$

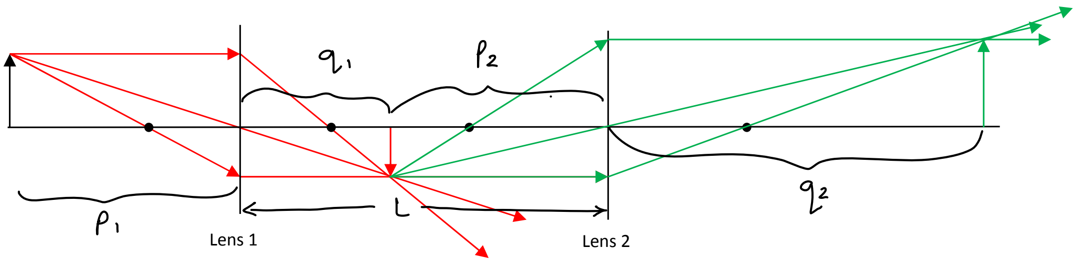
$$f_{beat} = |f_2 - f_1| = f_{os} - f_s = 926\text{Hz} - 912\text{Hz}$$

$$f_{beat} = 14\text{ Hz}$$

continued on page 8...

Student No.: ______________________

B3. An object is placed 25.0 cm from a first converging lens of focal length $f_1 = 10.0$ cm. A second converging lens with focal length $f_2 = 15.0$ cm is placed $L = 40.0$ cm to the right of the first converging lens.



(a) The above diagram shows the object, the two lenses, and their focal points. Draw the complete principal ray diagram for each lens, showing the locations of the intermediate and final images. (4 marks)

(b) Calculate the magnification produced by the first lens. (2 marks)

$\boxed{-0.667}$

$$\frac{1}{f_1} = \frac{1}{p_1} + \frac{1}{q_1} \Rightarrow q_1 = \left(\frac{1}{f_1} - \frac{1}{p_1}\right)^{-1}$$

$$q_1 = \left(\frac{1}{10.0\text{cm}} - \frac{1}{25.0\text{cm}}\right)^{-1} = 16.7\text{cm}$$

$$M_1 = \frac{-q_1}{p_1} = \frac{-16.7\text{cm}}{25.0\text{ cm}} = -0.667$$

(c) Calculate the position of the image formed by the second lens. If you did not obtain an answer for (b), use a value of −0.670. (2 marks)

$\boxed{42.1\text{ cm}}$

From the ray diagram, $p_2 = L - q_1$

$$p_2 = 40.0\text{cm} - 16.7\text{cm} = 23.3\text{ cm}$$

$$q_2 = \left(\frac{1}{f_2} - \frac{1}{p_2}\right)^{-1} = \left(\frac{1}{15.0\text{cm}} - \frac{1}{23.3\text{cm}}\right)^{-1} = 42.1\text{ cm}$$

(d) Calculate the total magnification for the two-lens system. If you did not obtain an answer for (c), use a value of 42.0 cm. (2 marks)

$\boxed{+1.21}$

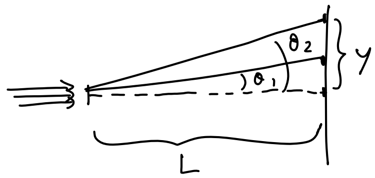
$$M_{tot} = M_1 \cdot M_2 = \left(-\frac{q_1}{p_1}\right)\left(-\frac{q_2}{p_2}\right)$$

$$M_{tot} = \frac{q_1 \cdot q_2}{p_1 \cdot p_2} = \frac{(16.7\text{cm})(42.1\text{ cm})}{(25.0\text{ cm})(23.3\text{ cm})} = +1.21$$

continued on page 9...

Student No.: ______________________

B4. Monochromatic light of wavelength λ is incident on a diffraction grating that has 8.00×10^3 lines/cm. A screen is placed 1.25 m from the grating. The second-order maximum of the interference pattern is observed at an angle of 45.0º relative to the incident direction.



$\theta_2 = 45.0°$

$L = 1.25\,m$

(a) Calculate the distance between consecutive slits of the ruling. (1 mark)

$\boxed{1.25 \times 10^{-6}\,m}$

$$d = \frac{1}{N} = \frac{1}{8.00 \times 10^3\,\text{lines/cm}} = 1.25 \times 10^{-4}\,cm$$

$$d = 1.25 \times 10^{-6}\,m$$

(b) Calculate the wavelength of the incident light. If you did not obtain an answer for (a), use a value of 1.30×10^{-6} m. (3 marks)

$\boxed{442\,nm}$

$$m\lambda = d\sin\theta \Rightarrow \lambda = \frac{d\sin\theta}{m}$$

$$\lambda = \frac{(1.25\times10^{-6}\,m)(\sin 45.0°)}{2} = 4.42 \times 10^{-7}\,m = 442\,nm$$

(c) Find the position of the second-order maximum on the screen, by calculating its distance from the centre of the interference pattern. (3 marks)

$\boxed{1.25\,m}$

$$\tan\theta_2 = \frac{y_2}{L} \Rightarrow y_2 = L\cdot\tan\theta_2$$

$$y_2 = (1.25\,m)(\tan 45.0°) = 1.25\,m$$

(d) Calculate the highest order of maximum for wavelength λ that can be observed with this grating. If you did not obtain an answer for (b), use a value of 453 nm. (3 marks)

$\boxed{2}$

highest possible order corresponds to $\theta = 90°$.

$$m\lambda = d\sin\theta \Rightarrow m_{max} = \frac{d\sin 90°}{\lambda}$$

$$m_{max} = \frac{(1.25\times10^{-6}\,m)}{4.42\times10^{-7}\,m} = 2.83$$

; but m must be an integer, $\therefore m_{max} = 2$

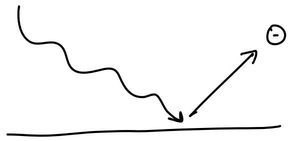
continued on page 10...

Student No.: ______________________

B5. The work function for zinc is 4.31 eV.

(a) Calculate the minimum frequency of light that will cause electrons to be released from a zinc surface. (3 marks)

$\boxed{1.04 \times 10^{15}\ \text{Hz}}$



Photoelectric Effect:

$$KE_{max} = hf - \phi$$

At minimum possible freq'y for which photoelectrons are released, $KE_{max} = 0$.

$$\therefore hf_{min} = \phi \Rightarrow f_{min} = \frac{\phi}{h} = \frac{4.31\ \text{eV}}{4.136 \times 10^{-15}\ \text{eV}\cdot\text{s}}$$

$$f_{min} = 1.04 \times 10^{15}\ \text{Hz}$$

(b) Calculate the maximum wavelength of light that will cause electrons to be released from a zinc surface. If you did not obtain an answer for (a), use a value of 9.83×10^{14} Hz or 1.10×10^{15} Hz. (2 marks)

$\boxed{288\ \text{nm}}$

From $v = f\lambda$, $\lambda_{max} = \dfrac{c}{f_{min}}$

$$\lambda_{max} = \frac{2.998 \times 10^{8}\ \text{m/s}}{1.04 \times 10^{15}\ \text{Hz}} = 2.88 \times 10^{-7}\ \text{m} = 288\ \text{nm}$$

(c) If photons of wavelength 225 nm are incident on a zinc surface, calculate the maximum speed of the ejected photoelectrons. (5 marks)

$\boxed{6.50 \times 10^{5}\ \text{m/s}}$

$$KE_{max} = hf - \phi = \frac{hc}{\lambda} - \phi$$

$$\frac{1}{2} m v_{max}^2 = \frac{hc}{\lambda} - \phi$$

$$v_{max} = \sqrt{\frac{2}{m}\left(\frac{hc}{\lambda} - \phi\right)}$$

$$v_{max} = \left[\frac{2\left(\frac{(6.626 \times 10^{-34}\ \text{J}\cdot\text{s})(2.998 \times 10^{8}\ \text{m/s})}{2.25 \times 10^{-7}\ \text{m}} - 4.31\ \text{eV} \times \frac{1.602 \times 10^{-19}\ \text{J}}{\text{eV}}\right)}{9.109 \times 10^{-31}\ \text{kg}}\right]^{1/2}$$

$$v_{max} = 6.50 \times 10^{5}\ \text{m/s}$$

continued on page 11...

B6. In lab MP9 you studied the radioactive decay of Indium-116.

(a) Given that Indium has an atomic number of 49 and that Indium-116 undergoes beta-negative decay, what are the atomic number and nucleon number of the isotope that is produced when Indium-116 decays? (2 marks)

$$^{116}_{49}In \rightarrow {}^{116}_{50}X + {}^{0}_{-1}e + {}^{0}_{0}\bar{\nu}$$

A: 116

Z: 50

(b) Do you expect the mass of the isotope produced by the decay of Indium-116 to be greater than or less than the mass of Indium-116? (1 mark)

Circle your choice:

greater less

Spontaneous decay ⇒ release of energy
⇒ conversion of mass to energy.

or// Daughter is more stable than parent, ∴ more binding energy, ∴ less mass

(c) Suppose that one of your MP9 measurements is a total count of 9860 during a 10.0-minute period of time. If the background count rate is 125 counts per minute, calculate the corrected count rate and express your answer in counts per minute. (2 marks)

861 /min

$$C_{corr} = C_{raw} - C_{bkgnd}$$

$$C_{corr} = \frac{9860}{10.0\,min} - \frac{125}{min} = 861/min$$

(d) The corrected initial count rate for a sample of Indium-116 is 1.45×10^4 counts per minute. 125 minutes later, the corrected count rate is 2.93×10^3 counts per minute. Calculate the half-life of Indium-116 and express your answer in minutes. (5 marks)

54.2 min

$$N = N_0 e^{-\lambda t} \text{ and } R = \lambda N \Rightarrow R = R_0 e^{-\lambda t}$$

$$\therefore \frac{R}{R_0} = e^{-\lambda t} \Rightarrow \ln\left(\frac{R}{R_0}\right) = -\lambda t \Rightarrow \lambda = \frac{-\ln(R/R_0)}{t}$$

$$\lambda = \frac{-\ln\left(\frac{2.93\times10^3/min}{1.45\times10^4/min}\right)}{125\,min} = 1.28\times10^{-2}/min$$

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{\ln 2}{1.28\times10^{-2}/min} = 54.2\,min$$

END OF EXAMINATION