

Chem3615 Quantum Mechanics Practice Problems

These problems will not be handed in but are to help you prepare for the midterm

1. Find the results of operating with $\hat{A} = x - \frac{d}{dx}$ and $\hat{B} = x + \frac{d}{dx}$ on the function $f(x) = e^{-\frac{x^2}{2}}$

$$\hat{A}F(x) = \left(x - \frac{d}{dx}\right)e^{-\frac{x^2}{2}} = xe^{-\frac{x^2}{2}} + xe^{-\frac{x^2}{2}} = 2xe^{-\frac{x^2}{2}}$$

$$\hat{B}F(x) = \left(x + \frac{d}{dx}\right)e^{-\frac{x^2}{2}} = xe^{-\frac{x^2}{2}} - xe^{-\frac{x^2}{2}} = 0$$

2. Which of the following functions is an eigenfunction of the operator $\frac{d}{dx}$? Give the eigenvalue where appropriate. k is a constant.

a. k $\frac{d}{dx}(k) = 0 = 0(k) \quad \therefore k$ is an eigenfunction with eigenvalues of 0

b. kx^2 $\frac{d}{dx}(kx^2) = 2kx \neq c(kx^2) \quad \therefore kx^2$ is not an eigenfunction

c. $\sin(kx)$ $\frac{d}{dx}(\sin(kx)) = k\cos(kx) \neq c(\sin(kx)) \quad \therefore \sin(kx)$ is not an eigenfunction

d. e^{kx} $\frac{d}{dx}(e^{kx}) = k(e^{kx}) \quad \therefore k$ is an eigenfunction with eigenvalues of k

e. e^{kx^2} $\frac{d}{dx}(e^{kx^2}) = 2kxe^{kx^2} \neq c(e^{kx^2}) \quad \therefore e^{kx^2}$ is not an eigenfunction

f. e^{ikx} $\frac{d}{dx}(e^{ikx}) = ik(e^{ikx}) \quad \therefore k$ is an eigenfunction with eigenvalues of ik

3. What is the value of the following commutators

a. $[\hat{x}, \hat{p}_x]f = \left[x\left(-i\hbar\frac{\partial}{\partial x}\right) - \left(-i\hbar\frac{\partial}{\partial x}\right)x\right]f = -i\hbar\left[x\frac{\partial f}{\partial x} - \frac{\partial(xf)}{\partial x}\right]$

$$[\hat{x}, \hat{p}_x]f = -i\hbar\left[x\frac{\partial f}{\partial x} - f - x\frac{\partial f}{\partial x}\right] = i\hbar f$$

$$\therefore [\hat{x}, \hat{p}_x] = i\hbar$$

b. $[\hat{x}, \hat{p}_x^2]f = \left[x\left(-\hbar^2\frac{\partial^2}{\partial x^2}\right) - \left(-\hbar^2\frac{\partial^2}{\partial x^2}\right)x\right]f = -\hbar^2\left[x\frac{\partial^2 f}{\partial x^2} - \frac{\partial^2(xf)}{\partial x^2}\right]$

$$[\hat{x}, \hat{p}_x^2]f = -\hbar^2\left[x\frac{\partial^2 f}{\partial x^2} - \frac{\partial}{\partial x}\left(f + x\frac{\partial f}{\partial x}\right)\right] = -\hbar^2\left[x\frac{\partial^2 f}{\partial x^2} - \frac{\partial f}{\partial x} - \frac{\partial f}{\partial x} - x\frac{\partial^2 f}{\partial x^2}\right]$$

$$[\hat{x}, \hat{p}_x^2]f = 2\hbar^2\frac{\partial f}{\partial x}$$

$$\therefore [\hat{x}, \hat{p}_x^2] = 2\hbar^2\frac{\partial}{\partial x}$$

c. $[\hat{x}, \hat{p}_y]f = \left[x\left(-i\hbar\frac{\partial}{\partial y}\right) - \left(-i\hbar\frac{\partial}{\partial y}\right)x\right]f = -i\hbar\left[x\frac{\partial f}{\partial y} - x\frac{\partial(f)}{\partial y}\right] = 0$

$$\therefore [\hat{x}, \hat{p}_y] = 0$$

4. Angular momentum, L , is given by the cross product $r \times p$. So the angular momentum in the x axis, L_x , is given by $yp_z - zp_y$, what is the operator \hat{L}_x ?

$$\hat{L}_x = y\left(-i\hbar\frac{\partial}{\partial z}\right) - z\left(-i\hbar\frac{\partial}{\partial y}\right) = -i\hbar\left(y\frac{\partial}{\partial z} - z\frac{\partial}{\partial y}\right)$$

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Detailed solutions are provided **Quantum Mechanics I** S. Rajasekar,R. Velusamy,2014-12-11 Quantum Mechanics I The Fundamentals provides a graduate level account of the behavior of matter and energy at the molecular atomic nuclear and sub nuclear levels It covers basic concepts mathematical formalism and applications to physically important systems The text addresses many topics not typically found in books at this level includin **Quantum Mechanics :Through Problems** V. K. Thankappan,2003 The Importance Of Problem Solving In Understanding The Principles And Applications Of Quantum Mechanics Cannot Be Over Emphasized As Such The Book Will Be A Valuable Tool For The Students Of Quantum Mechanics The Book Is Divided Into Two Parts The First Part Is Composed Of 8 Chapters Entitled Linear Vector Spaces Quantum Dynamics Theory Of Angular Momentum Symmetry And Conservation Laws Scattering Theory Approximation Methods Identical Particles And Relativistic Wave Equations Each Chapter Consists Of A List Of Problems Preceded By A Brief Write Up On The Topic Of The Chapter The Detailed Solutions To The Problems Are Given In The Second Part Chapter 9 Which Is Divided Into Sections Each Section Corresponding To A Chapter Of The Same Title Such A Physical Separation Of The Solutions From The Problems Is Intended To Encourage Students To Attempt Their Own Solutions Before Looking Up The Solutions Given In The Book *Fundamentals of Physics* David Halliday,Robert Resnick,Jearl Walker,2010-03-15 This book arms engineers with the tools to apply key physics concepts in the field A number of the key figures in the new edition are revised to provide a more inviting and informative treatment The figures are broken into component parts with supporting commentary so that they can more readily see the key ideas Material from The Flying Circus is incorporated into the chapter opener puzzlers sample problems examples and end of chapter problems to make the subject more engaging Checkpoints enable them to check their understanding of a question with some reasoning based on the narrative or sample problem they just read Sample Problems also demonstrate how engineers can solve problems with reasoned solutions INCLUDES PARTS 1 4 PART 5 IN FUNDAMENTALS OF PHYSICS EXTENDED **Class 11-12 Chemistry MCQ (Multiple Choice Questions)** Arshad Iqbal,2019-05-17 The Class 11 12 Chemistry Multiple Choice Questions MCQ Quiz with Answers PDF College Chemistry MCQ PDF Download Quiz Questions Chapter 1 6 Practice Tests with Answer Key 11th 12th Grade Chemistry Questions Bank MCQs Notes includes revision guide for problem solving with hundreds of solved MCQs Class 11 12 Chemistry MCQ with Answers PDF book covers basic concepts analytical and practical assessment tests Class 11 12 Chemistry MCQ PDF book helps to practice test questions from exam prep notes The Class 11 12 Chemistry MCQs with Answers PDF eBook includes revision guide with verbal quantitative and analytical past papers solved MCQs Class 11 12 Chemistry Multiple Choice Questions and Answers MCQs PDF Free download chapter 1 a book covers solved quiz questions and answers on chapters atomic structure basic chemistry chemical bonding chemistry experimental techniques gases liquids and solids tests for college and university revision guide Class 11 12 Chemistry Quiz Questions and Answers PDF free download eBook s sample covers beginner s solved questions textbook s study notes to practice online tests The book Grade

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