# VP390 Review 3

**Pan, Chongdan ID:516370910121**

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1. What does the de Broglie hypothesis say?
   **Everything has the property of wave**

2. Write down the de Broglie relations between (a) the momentum and the wave number, (b) the energy and the angular frequency.
   $k = \frac{p}{\hbar}, \omega = \frac{E}{\hbar}$

3. The length of the de Broglie wave of an electron in the first Bohr orbit of a hydrogen atom is much $\cdots$ than that of a cricket ball moving at 10 m/s.
   **Larger**

4. Write down the general form of the classical wave equation (1D). Give two specific examples from classical physics
   $\frac{\partial^2 \zeta}{\partial x^2} = \frac{1}{v_{ph}^2} \frac{\partial^2 \zeta}{\partial t^2}$

5. What is a (classical) wave packet?
   **A superposition of waves with different** $\omega$

6. What is the group velocity? Is it equal to the phase velocity?
   **The velocity of envelop, not equal**

7. Given the angular frequency and the wave number, how can we find the phase velocity? Group velocity?
   $v_{ph} = \frac{\omega}{k}, v_g = v_{ph} + k\frac{\partial v_g}{\partial k} = \frac{\omega}{\mathrm{k}}$

8. What do we mean when we say that a wave is dispersive?
   **Wave with different length travels with different** $v_{ph}$

9. What is the classical uncertainty relation? Illustrate with a sketch
   $\triangle x \triangle k \approx 1$

10. When is a function said to be square-integrable?
    $\inf |\Psi(x,t)|^2 \neq \infty$

11. Let $\Psi(x,t)$ describe a quantum particle in a certain state. How do we calculate the average position of the particle? The variance of the position? (Give formulas.)
    $\langle x \rangle , \sqrt{\langle x^2 \rangle - \langle x \rangle^2}$

12. What is a stationary state
    $\Psi(x,t) = \phi(x)$

13. Write down the (time-dependent) Schrodinger equation.
    $-\frac{\hbar^2}{2m}\frac{\partial^2\Psi(x,t)}{\partial x^2} + V(x)\Psi(x,t) = i\hbar\Psi(x,t)$

14. How do we represent physical (i.e. measurable) quantities in quantum mechanics?
    **Hermitian operator**

15. What is the form of the position operator? momentum operator? kinetic energy?
    $x, -i\hbar\frac{\partial}{\partial x}, -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$

16. What is the Hamiltonian of a quantum system?
    **Total energy operator**

17. Write down a generic equation for eigenvalues and eigenfunctions of an operator. Identify which symbols represent the operator, the eigenvalue and the eigenfunction
    $c_m = \langle\psi_m, \phi\rangle$

18. If $\psi_E$ is a solution of the stationary Schrodinger equation, then the corresponding solution of the full (time-dependent)
    $e^{-\frac{i}{\hbar}Et}\psi_E$