Industrial and Engineering Chemistry PHYSICS
Exam requirements, May 2010

1. Can you have zero acceleration and nonzero velocity? Explain using a vx vs. t graph.
2. Can an object be increasing in speed as its acceleration decreases? If so, give an example. If not, explain.
3. Under what conditions is it possible to have a constant speed yet a nonzero acceleration?
4. What factors determine how far an athlete travels in the long jump? Which factor do you think must be the most important?
5. Derive the formula $s = s_0 + v_0 t + a\frac{t^2}{2}$ from the basic kinematic assumptions.
6. Explain what is described by the projectile motion concept.
7. If there is a net force on a particle in uniform circular motion, why does the particle's speed not change?
8. Formulate the Pascal law and comment in its applications.
9. With a little effort you can blow across a dime on a table and make it land in a cup. Explain!
10. Derive Bernoulli's equation from the Euler's one.
11. Derive the law of reflection based on the "least action" principle.
12. Derive Snell's law of refraction based on the "least action" principle.
13. Describe and explain the photoelectric effect.
14. Derive the Planck radiation law for the "black body".
15. Comment on the "ultraviolet catastrophe".
16. Does a car bounce on its springs faster when it is empty or when it is fully loaded?
17. Is the acceleration of a simple harmonic oscillator ever zero? Is so, when? What about a dumped harmonic oscillator?
18. Tell the difference and comment on refraction and diffraction.
19. Derive the $1 - D$ wave equation.
20. Show that quantization of the angular momentum postulated by Bohr is easily derived from de Broglie concept of an electron as a standing wave.

21. If a proton and an electron have the same speed, which has the longer de Broglie wavelength? Explain.

22. If a proton and an electron have the same kinetic energy, which has the larger de Broglie wavelength? Explain.

23. Why can an electron microscope have greater magnification than an ordinary microscope?

24. Derive the Coulomb law from the Gauss law for an electric field.

25. Show that an electrostatic field is a potential field.

26. Derive a relation between potential and voltage.

27. Derive a relation between the strength of an electric field and its potential.

28. Derive Laplace and Poisson's equations from the Gauss law and condition for potentiality of an electrostatic field.

29. Define the second law of Newton and explain how to handle multiple forces.

30. Define third law of Newton, and explain it on the example of gravitational interaction of a body standing on the ground.

31. Explain why does the friction coefficient not depend on the surface.

32. Define the coefficients of static, kinetic and rolling friction, explain which of them applies to what situation.

33. What is the relation between friction and heat?

34. Comment on the energy conservation principle. Explain the energy changes of a stone hanging on the height h, which is dropped down and stops the motion after hitting the ground.

35. Explain why the line integral is needed to calculate work in a force field?

36. What is the difference between formulas $\vec{C} = \vec{A} \times \vec{B}$ and $C = AB \sin \alpha$?

37. If $\vec{v} = \vec{w} \times \vec{r}$, derive the formula for velocity components in motion in the circle.

38. How does the x and y component of the position change in circular motion?

39. What is the difference between centripetal and centrifugal force?

40. Why is the centrifugal force considered to be an apparent force?

41. Considering the energy of individual point particle in the rigid body equal to $dE_k = \frac{dmv^2}{2}$, derive the formula for the energy of rotating rigid body $E = \frac{I\omega^2}{2}$.

42. Explain the analogy between laws of transitional and rotational dynamics.
43. Why does the ice skater spin slower when he expands his arms?
44. Derive the continuity equation. Why is the incompressibility required?
45. Derive the Bernoulli equation from the work-energy theorem.
46. Explain and comment the relations in the Newtonian viscosity equation.
47. Show the similarities in the Poiseuille law and the Newton viscosity force.
48. What is the random walk problem?
49. How to solve the diffusion equation by separation of variables?
50. Derive Schroedinger equation from the de Broglie relation and wave equation.
51. What is the difference between formulas $E = \frac{p^2}{2m}$ and $E = h\nu$?
52. What is the Born interpretation of the wave function?
53. What is the difference between the electron orbital and the electron cloud?
54. What is the difference between most probable and average position of the electron in Bohr atom in the lowest energy state?
55. Derive the "sandwich" formula for calculating averages in quantum mechanics.
56. Comment on the uncertainty principle with respect to momentum, position, time and energy. Show some example applications of this principle.
57. What for do we need operators in quantum mechanics? Where is the complete state description of a quantum object?
58. Explain the variational principle.
59. Show the interpretation of gradient by the analogy to walking in the mountains.
60. Write down the Coulomb force and comment the vectorial and non-vectorial form of the equation.
61. Write down Lorentz transformations for time and position. Explain the experiment that supports these transformations.
62. From the Lorentz transformations, derive the relativistic summation of velocities.
63. Show 3 examples of time dilation in real life.

64. Using the concept of length contraction and time dilation explain how is it possible to travel a distance of 1mln light years during the life of a single person.

65. Derive the relativistic kinetic energy from the work-energy theorem.

66. Comment on "Impulse-Momentum" theorem and the Newton's law in case when mass depends on time

67. Consider the following situation: you release a rock at the surface of a very deep pond. If the fluid resistance force is given by the formula $F = kv$, what are the acceleration, velocity and position of the rock as function of time?

68. Show that the "work-energy theorem" holds even when the force varies during the displacement.

69. Derive the formula for acceleration in case of motion in a circle

70. If you dangle two pieces of paper vertically, a few inches apart, and blow between them, how do you think the papers will move? Explain in details.

71. Can a small force exert a greater torque than a large force? Explain.

72. What is the work done by a torque? Derive the formula and comment.

73. You can blow across a dime on a table and make it land in a cup. Explain.

74. Two ships moving in parallel path close to one another risk colliding. Why?

75. How could you double the maximum speed of a SHO?

76. Tell and comment the difference between Gauss law and Gauss theorem on divergence.

77. Write down and describe the physical interpretation of Maxwell's eqs. in integrated form.

78. Show the way from integrated to differential form of Maxwell's equations. Comment on local and global quantities involved.