Biomedical Engineering Department
Cairo University

Time Allowed: One Hour
Open-Book/Open-Notes

Medical Equipment I Sample Mid-Term Exam
November 2011

Solve as Much as You Can – Maximum Grade: 100 Points

Part I. Answer the following questions by marking the best answer among the choices given [2 points each]:

1. To transport a solute for a short distance, … would be the most efficient phenomenon to do that.
   a) Solvent drag
   b) Perfusion
   c) Diffusion
2. The half-life time of a process with decay constant of 1 s^{-1} is …
   a) 0.693 s
   b) 0.231 s
   c) 0.347 s
3. The plot of the function f(x) = x^2 appears … on a semilog plot.
   a) linear
   b) piecewise linear
   c) nonlinear
4. The plot of the function f(x)= $5e^{2x}$ has an intercept of … on a semi-log plot.
   a) 5
   b) 2
   c) $2x$
5. Buoyancy force on terrestrial animals in air is negligible because …
   a) Density of aquatic animals is close to that of water
   b) Density of terrestrial animals is much higher than that of air
   c) Volume of aquatic animals is much smaller than that of terrestrial animals
6. Heavier particles in Brownian motion move with a speed that is … lighter particles of smaller size.
   a) higher than
   b) lower than
   c) the same as
7. The First law of thermodynamics is equivalent to …
   a) Conservation of mass
   b) Conservation of energy
   c) Thermal equilibrium
8. If the half-life of ^{99m}Tc is 6 hours, then it will reach … of its initial rate after 12 hours.
   a) half
   b) third
   c) quarter
9. Consider a system with $N>100$ particles each having one of two states with probability 0.12 and 0.88 respectively. The total number of macrostates in the system should be …
   a) $2N$
   b) 2^N
   c) $<N$
10. Clearance of a metabolite from the plasma through the kidneys follows … equation.
    a) Exponential decay
    b) Linear decrease
    c) Logistic

11. For a gas at standard temperature and pressure, if the volume of 1 mol is 22.4 liters and the radius of its molecules is 0.2 nm, then the mean free path is …
    a) 0.13 µm
    b) 0.10 µm
    c) 0.07 µm
12. A process in which the change in a quantity Q with respect to time is proportional to the quantity itself is called …
    a) An exponential curve
    b) A quadratic curve
    c) A linear curve
13. Undesirable or unexpected events resulting from the interaction between a user and a device is called …
    a) Slip
    b) Lapse
    c) User error
14. Omitting steps in a device operating procedure is classified as …
    a) Slip
    b) Lapse
    c) Mistake
15. With respect to medical devices, harm does not include …
    a) Delayed treatment
    b) Injury to patient
    c) Fatigue of device operator
16. Solvent drag means …
    a) Solute particles drifting with solvent
    b) Solvent attracting solute molecules by diffusion
    c) Newtonian flow of solvent
17. Entropy of a system is maximum at …
    a) Low temperatures
    b) High temperatures
    c) Equilibrium
18. Consider the combined decay of two processes with decay constants 1 and 2 s^{-1} respectively. Then, the half-life time as a result of both processes is given by …
    a) 0.693 s
    b) 0.231 s
    c) 0.347
19. One method for use-related hazard mitigation strategies can be …
    a) FMEA
    b) Decision on whether risks are acceptable
    c) Modification of intended use
20. An important task in risk management after the product is marketed is to …
    a) Track sales volumes compared to predecessor devices
    b) Track incidents of user complaints and device returns
    c) Conduct usability testing

Part II. Mark the following statement as either True (T) or False (F) (1 point each):

21. Users regard action confirmation messages as a wasted extra step and therefore should be avoided.
22. Medical devices designed with multiple operational modes must clarify the present operating mode to the user.
23. When possible, medical monitoring device designs should help users forecast patient variables.
24. Mistakes arise from applying the wrong knowledge when making a decision.

25. Validation must be done by clinicians whereas verification is mainly done by design engineers.
26. After implementing design change to mitigate a risk, new risks may arise as a result of this change.
27. The Boltzmann factor is used to derive the Nernst equation.
28. Systems of many particles that are in equilibrium tend to change with time toward equilibrium.
29. Isolation of an infectious compartment can be done using laminar flow principles.
30. Diffusion is the main mechanism for oxygen transport from capillaries to cells.
31. Osmotic pressure has a value only when using permeable membranes.
32. For a process with multiple decay paths, overall decay constant is smaller than the decay constant of any of its components.
33. Diffusion happens as a result of Brownian motion and solvent drag of particles in a fluid.
34. When the probability of one of the available microstate is 1, the system is at equilibrium.
35. Diffusion happens as a result of Brownian motion of particles in a fluid.
36. When the probability of all available microstates is the same, the system is at equilibrium.
37. The entropy of a system is equal to the root mean square of entropies of its subsystems.
38. It is possible to use classical mechanics to describe systems of many particles when needed.
39. Entropy change is related to mechanical work.
40. Exponential growth can be plotted as a linear curve using log-log plots.

Part III. Solve the following problems (10 points each):

41. Compute an approximate figure for the number of cells in a cat.

42. The potential energy of hydrogen nuclei in a magnetic field is equal to ($\gamma\, m\, B\, h/2\pi$) where γ is the gyromagnetic ratio (42.6 MHz/T), h is the Planck's constant given by 6.626×10^{-34} and B is the magnetic field, and m is the spin number that takes the values of either + ½ or – ½ . Calculate the probability of spins with m= ½ relative to that with m= – ½ at magnetic field B= 3 T and temperature of 300° K. Assume a unity density of states factor.

43. Consider three systems A, A', and A'' that are in thermal contact with each other but are isolated from the rest of the universe. Each of the 3 systems has two particles. The energy levels each particle may have u, 2u, 3u, etc. Let the total energy be U*= 10u. Compute the number of microstates for the whole system A*.

Best of luck!