Biomedical Engineering Department **Time Allowed: Two Hours**
Cairo University **Open-Book/Open-Notes**

Medical Equipment I Term Exam
January 17, 2009

Solve as Much as You Can – Maximum Grade: 75 Points

Part I. Answer the following questions by marking the best answer among the choices given [1 ½ points each]:

1. In order to study propagation of nerve impulses through an axon, we assume …
a) no current through the membrane
b) no current along the axon (*)
c) no current between inside the axon and the extracellular space

2. If a local anesthesia is given at location 0 and assuming the membrane capacitance per unit area to be small, the area of the anesthetized tissue depends on …
a) Resistance per unit length along inside of axon (*)
b) Resistance per unit length along outside of axon
c) Conductivity per unit length of the membrane of axon

3. For electrotonus spread, we assume …
a) Ohmic membrane (*)
b) Membrane capacitance per unit area to be zero
c) No dependence on x

4. The depolarization peak in action potential happens when …
a) The membrane chlorine channels open
b) The membrane potassium channels open
c) The membrane sodium channels open (*)

5. The empirical equations for speed of conduction in myelinated and unmyelinated fibers can be derived from measured data using …
a) linear plots
b) semi-log plots
c) log-log plots (*)

6. The electrostatic force on a spherical shell of radius R with charge q_1 resulting from a charge q_2 at a distance L from its center can be computed using …
a) Coulomb's law
b) Newton's third law
c) Coulomb's law and Newton's third law together (*)

7. Dielectrics differ from conductors in having a nonzero … when placed in an electric field.
a) Polarization field (*)
b) External field
c) Resistance

8. Kirchhoff's first law is a direct consequence of …
a) Conservation of energy
b) Conservation of charge (*)
c) Conservation of mass

9. For a segment of an axon of length 10 μm and radius 5 μm, the membrane surface area is …
a) 785 μm^2
b) 314 μm^2(*)
c) 50 μm^2

10. Edema can occur when there is …
a) an increase in osmotic pressure inside capillaries
b) an increase in osmotic pressure in extracellular space (*)
c) an increase in level of medium-weight molecule inside blood

11. In artificial kidney using cellophane membrane dialyzer, if ωRT is 5×10^{-6} m/s, surface area of dialyzer is 3 m^2, and body fluid volume is 40 l, the time required for treatment is approximately …
a) 3.3 hours
b) 2.2 hours (*)
c) 1.1 hours

12. Headaches in renal dialysis can be reduced by …
a) Reducing treatment time constant
b) Increasing treatment time constant (*)
c) Injecting urea in the blood

13. Osmotic pressure is associated with … membranes.
a) semipermeable (*)
b) permeable
c) permeable and semipermeable

14. Mass fluence rate has units of …
a) kg s^{-1}
b) kg m^{-2}
c) kg m^{-2} s^{-1} (*)

15. Solvent drag means …
a) Solute particles drifting with solvent (*)
b) Solvent attracting solute molecules by diffusion
c) Newtonian flow of solvent

16. Brownian motion of a particle implies that the mean velocity of the particle is …
a) 0 (*)
b) $\sqrt{3k_BT/m}$
c) $\sqrt{3k_BT/2m}$

17. The collision cross-section of a particle of radius a_1 when passing through a medium of stationary particles of radius a_2 is …
a) $\pi a_1^2 + \pi a_2^2$
b) $\pi (a_1 + a_2)^2$ (*)
c) $\pi (½ (a_1 + a_2))^2$

18. The assumptions used to derive expression for mean free path in gases were justified by …
a) Verifying that mean free path is more than 1000 times that of the size of the particle (*)
b) Verifying that collisions are indeed frequent
c) Verifying that the same expression is also valid in liquids

19. Fick's second law of diffusion combines …
a) Fick's first law of diffusion and the continuity equation (*)
b) Fick's first law of diffusion and Einstein relationship
c) Einstein relationship and the conservation of mass

20. Entropy of a system is maximum at …
a) Low temperatures
b) High temperatures
c) Equilibrium (*)

21. 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 s

22. The plot of the function f(x)= x^2+1 appears … on a log-log plot
a) linear
b) piecewise linear
c) nonlinear (*)

23. The The plot of the function f(x)= e^x has an intercept of … on a semi-log plot.
a) 0
b) 1 (*)
c) x

24. Buoyancy force for aquatic animals is much less than that of terrestrial animals because …
a) Density of water is close to that of aquatic animals (*)
b) Density of air is close to that of terrestrial animals
c) Volume of terrestrial animals is much larger than that of aquatic animals

25. To reach double the diffusion distance, the diffusion time required must be multiplied by …
a) ½
b) 2
c) 4 (*)

26. Heavier particles in Brownian motion move … lighter particles of the same size.
a) Faster than
b) Slower than (*)
c) As fast as
27. Accessing C8051F020 memory location 0F0H using indirect addressing mode refers to …
a) Special function register
b) memory address (*)
c) Immediate value

28. For low-cost microcontroller applications, one should use a system clock based on …
a) RC oscillator
b) Crystal oscillator
c) The microcontroller's own internal oscillator (*)

29. Microcontroller counters can be used to …
a) Schedule periodic check on the status of a process
b) Reset the microcontroller when runs out of control
c) Measure the number of particular events of interest (*)

30. Using a 3.3V microcontroller, a GPIO pin can provide TTL-compatible output with levels using …
a) A push-pull output mode (*)
b) A push-pull output mode with internal weak pull-ups
c) An open-drain output mode

Part II. Mark the following statement as either True (T) or False (F) (½ point each):

31. Superposition is used to compute electric field from several charges but not to compute the electrostatic forces (F)
32. Gauss's law can be used to derive Coulomb's law (T)
33. Potential difference has units of energy per unit charge (T)
34. Capacitance is composed of two plates with equal charge separated by a small distance (F)
35. Countercurrent transport is better because it removes solutes at an exponential rate with distance (F)
36. The properties of capillary-brain barrier in the reason for headaches in renal dialysis (T)
37. The net transport of water across a semipermeable membrane depends only on osmotic pressure (F)
38. Particle flux is defined as the total volume of material transported per unit time (F)
39. Mean free path in liquids has a different form than that of gases (T)
40. Equilibrium is the most random, most probable state (T)
41. Heat flow causes no change in positions of energy levels (T)
42. If a system is not in equilibrium, it tends to change with space until it is in equilibrium (F)

43. A system that has adiabatic walls does not interact with surroundings (T)
44. Entropy change is related to mechanical work (F)
45. Exponential growth cannot be plotted using semi-log plots (F)
46. Functions with variable exponential decay rate cannot be analyzed using semi-log plots (F)
47. Work is calculated as the area under the pressure-volume curve (T)
48. Isolation of an infectious compartment can be done using semipermeable membranes (F)
49. A process in which the change in quantity Q with time is proportional to Q is a semilog process (F)
50. Microcontroller clock configuration must perform a check on the internal clock validity (F)

Q3. Denote the following C8051F020 microcontroller instructions as either being true (T) or false (F) assembly instructions. [½ point each]

51.	`SUBB R2, F0H`	(F)
52.	`XRL 70H, A`	(T)
53.	`MOV 40H , #FFH`	(T)
54.	`ADD A, #30H`	(T)
55.	`DA R1`	(F)
56.	`DJNZ R6, 70H`	(T)
57.	`CPL P1.6`	(T)
58.	`SETB C`	(T)
59.	`INC @R7`	(F)
60.	`DIV AB`	(T)

Q4. Compute the output of the following operations in a C Language program for a C8051F020 device [½ point each]

61.	`00100100b && 10100001b`	(ans: TRUE)
62.	`0F0H + 00AH`	(ans: 0FAH)
63.	`055H & 0AAH`	(ans: 000H)
64.	`~0F0H`	(ans: 00FH)
65.	`0F0H ^ 10100001b`	(ans: 01010001b)
66.	`!(00100100b & 00000001b)`	(ans: TRUE)
67.	`(0F0H - 080H) == 0`	(ans: FALSE)
68.	`0F1H % 02H`	(ans: 1)
69.	`040H>>2`	(ans: 010H)
70.	`(0FEA0H & 080H)`	(ans: 0080H)

Q5. [5 points] Consider a project in which the 4-bit digital data from an A/D is connected to pins 4-7 of port 1 of your C8051F020 ToolStick University Daughter Card. Write a program that inputs the value of the digital data lines connected to P1.4-P1.7 and turns on/off the corresponding LEDs connected to P5.4-P5.7 based on the value read. (That is, if the P1.0 is 1 then the LED at P5.4 is lit, and if the P1.4 is 0 then the LED P5.4 is off, and so on for the other pins).

Similar to Exercise E of Lab 3 but you need to make the necessary changes to use Port 1 instead of the DIP switches on Port 4

Q6. [5 points] In ultrasound imaging, it is required to have an ultrasound pulse sent every 300µs to the body. Provide the programming sequence of a microcontroller timer to generate a periodic signal with a period of 300µs and an ON time of the signal of 1µs. [Hint: it is required to provide the timer programming part only]

Similar to Exercise C of Lab 5 but here you will have a simpler case of a fixed parameter PWM signal (i.e., On and Off times are fixed and do not change with DIP switches.

Q7. [5 points] Consider the problem of gas exchange between blood and air in alveoli. If the average radius for alveoli is 100 µm and that for capillaries is 4µm and given that the diffusion constant in air is 2×10^{-5} and in water is 2×10^{-9} m^2s^{-1}, calculate time required for oxygen to diffuse from the center of an alveolus to the center of a blood capillary in contact with it in case of a patient with lung edema. Assume the lung edema to cause an additional small layer of fluid of thickness 2 µm

between the capillary and the lung alveolus in contact with it. Assume also that the diffusion constants in blood and extracellular fluid are the same as that of water.

Solution: Same steps as problem 4.18 with only an added layer of the extra fluid between the alveolus surface and the capillary

Best of luck!