國立中山大學 103 學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學【醫科所碩士班選考】　　題號：428001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

1. (a) A continuous-time signal $x(t)$ is defined by the following formula:

$$x(t) = \sum_{k=-8}^{8} \frac{j\pi k}{k^2+1} e^{j20\pi kt}$$

Determine the Nyquist rate for sampling $x(t)$ in the unit of Hz or in samples per second. (10%)

(b) A chirp signal is defined as: $x(t) = \cos(400\pi t^2)$. If the sampling rate is 800 Hz, the output signal will have time-varying frequency content. Draw a graph of the resulting analog instantaneous frequency (in Hz) versus time of the signal at $t = 0$ to 5 sec after reconstruction. (10%)

2. A linear time-invariant system is described by the difference equation: $y[n] = x[n] - x[n-4]$. (20%)

(a) Find its system function $H(z)$. (4%)

(b) Plot the poles and zeros of $H(z)$ in the z-plane. (4%)

(c) Find the frequency response $H(e^{j\omega})$ and express it in polar form (magnitude and phase). (6%)

(d) Sketch $|H(e^{j\omega})|$ for $-\pi < \omega < \pi$. (6%)

3. Solve $y(t)$ by using Laplace transform. (20%)

$$y'' + 4y' + 3y = e^t; \text{ and } y(0) = 0, y'(0) = 2.$$

4. Derive the general solution of $\mathbf{X}(t)$ according to the following differential equation. (20%)

$$\mathbf{X}' = \begin{pmatrix} 5 & -4 & 4 \\ 12 & -11 & 12 \\ 4 & -4 & 5 \end{pmatrix} \mathbf{X}$$

5. For

$$\mathbf{A} = \begin{pmatrix} 1 & 4 \\ 2 & 3 \end{pmatrix},$$

find an expression for $\mathbf{A}^n$, where n is an arbitrary positive integer. (20%)

國立中山大學103學年度碩士暨碩士專班招生考試試題

科目名稱：生理學【醫科所碩士班選考】　　題號：428002

※本科目依簡章規定「不可以」使用計算機　　

1. Describe two mediated transports across a cell membrane. (20%)

2. Describe why the resting membrane potential is always negative and how an action potential is formed. (20%)

3. Describe the auditory system from the tympanic membrane (eardrum) to the cochlea. When is tinnitus created? (20%)

4. Draw the action potential of a ventricular muscle cell with the action of sodium, potassium, and calcium channels. (20%)

5. Describe two hormones released by the posterior pituitary gland and six hormones released by the anterior pituitary gland. How does hypothalamus control the hormone release of the pituitary gland? (20%)

國立中山大學 103 學年度碩士暨碩士專班招生考試試題

科目名稱：普通化學【醫科所碩士班選考】　　題號：428004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

Part I. Multiple Choice (including single choice) (30%)

1. Which statement about bonding molecular orbitals is **correct**?
   (a) Electrons in bonding orbitals tend to stabilize the molecule.
   (b) Only σ bonds can result from bonding molecular orbitals.
   (c) In a bonding molecular orbital, the electron density is high between the two atoms.
   (d) Bonding molecular orbitals result from *in phase* overlap of the wave functions of the atomic orbitals.
   (e) The relative numbers of electrons in bonding versus antibonding orbitals determines the overall stability of the molecule.

2. Estimate the heat of reaction at 298 K for the reaction shown, given the average bond energies below:

   $$Br_2(g) + 3F_2(g) \rightarrow 2BrF_3(g)$$

Bond	Bond Energy
Br-Br	193 kJ/mol
F-F	155 kJ/mol
Br-F	249 kJ/mol

   (a) –836 kJ　(b) –150 kJ　(c) –89 kJ　(d) –665 kJ　(e) –1222 kJ

3. Nitrogen (atomic mass = 14.0067 amu) has two naturally occurring isotopes. The masses of ^{14}N and ^{15}N are 14.003074 and 15.000108 amu, respectively.
   What is the percent abundance of ^{15}N?

   (a) 15.0001%　(b) 14.0031%　(c) 99.635%　(d) 0.365%　(e) 0.0104%

4. The first ionization energy of sulfur (1005 kJ/mol) is less than that of phosphorus (1060 kJ/mol). Reasonable explanations for this fact involve:
   (a) the stability of the half-filled subshell in atomic sulfur.
   (b) pairing of two electrons in one 3*p* orbital in sulfur atoms.
   (c) the smaller size of sulfur atoms relative to phosphorus atoms.
   (d) the electron-electron repulsion cause the fourth *3p* electron in sulfur to be easily removed.
   (e) the larger effective nuclear charge Z_{eff} of sulfur atoms

5. What are the number of protons, neutrons, and electrons in the $^{34}_{16}S^{2-}$ ion.
   (a) 16 p, 18 n, 16 e　(b) 16 p, 18 n, 14e　(c) 16 p, 16 n, 19 e
   (d) 16 p, 18 n, 18 e　(e) 34 p, 16 n, 18 e

6. The second law of thermodynamics states:
   (a) All exothermic processes also increase entropy.
   (b) The enthalpy of the universe always increases in spontaneous processes.
   (c) A spontaneous process always increases entropy.
   (d) $\triangle H < 0$ and $\triangle S > 0$ for all spontaneous processes
   (e) The entropy of the universe always increases in spontaneous processes.

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7. Consider CH_4 and CF_4. Electronegativities: C = 2.5, H = 2.1, F = 4.0. Which statement is true?

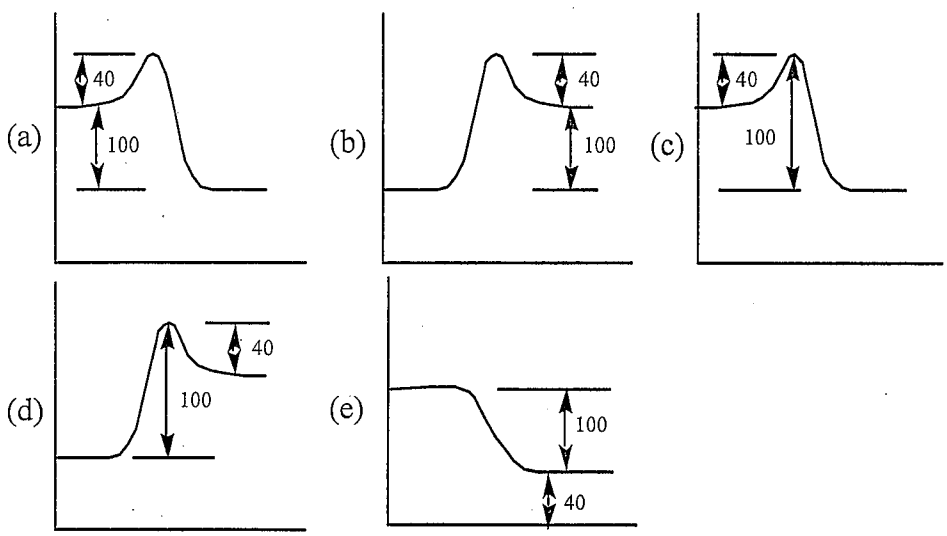
(a) Both are sp^3 hybridized at carbon.
(b) The bond angles in CF_4 are smaller than those in CH_4.
(c) The C-F bonds are more polar than the C-H bonds.
(d) Both molecules are nonpolar.
(e) The bond dipoles in CF_4 are directed toward the fluorine, but those in CH_4 are directed toward the carbon atom.

8. What is the bond order for each of the following species: N_2, N_2^-, N_2^+ and which one would be predicted to have the shortest bond length?

	bond order			shortest bond length
	N_2	N_2^-	N_2^+	
(a)	3	3.5	2.5	N_2^+
(b)	3	2.5	2.5	N_2
(c)	3	4	2	N_2^-
(d)	2	3	1	N_2^-
(e)	3	4	2	N_2^-

9. A catalyst
(a) increases the amount of products present at equilibrium.
(b) increases the rate at which equilibrium is reached but decreases the equilibrium constant.
(c) increases the rate at which equilibrium is reached without changing the equilibrium constant.
(d) increases $\triangle H$ for the process.
(e) lowers the activation energy by changing the reaction pathways.

10. A reaction has an activation energy of 40 kJ and an overall energy change of reaction of –100 kJ. In each of the following potential energy diagrams, the horizontal axis is the reaction coordinate and the vertical axis is potential energy in kJ. Which potential energy diagram best describes this reaction? (single choice)



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11. The gas phase reaction A + B → C has a reaction rate which is experimentally observed to follow the relationship rate = $k[A]^2[B]$. Which one of the following would affect the value of the specific rate constant, k?

(a) increasing the temperature
(b) changing the concentration of A
(c) changing the concentration of B
(d) adding a catalyst
(e) all of the above

12. What volume of 0.1125 M $K_2Cr_2O_7$ would be required to oxidize 48.16 mL of 0.1006 M Na_2SO_3 in acidic solution? The products include Cr^{3+} and SO_4^{2-} ions.

(a) 14.36 mL
(b) 28.75 mL
(c) 43.12 mL
(d) 56.12 mL
(e) 32.15 mL

13. For real gas, it follows $(P + \frac{n^2a}{V^2})(V - nb) = nRT$. Which one of the statements is true?

(a) A real gas behaves more nearly as an ideal gas at high temperatures and low pressures.
(b) In the van der Waals equation, the "a" factor corrects for attractive forces, and one would expect a larger value of "a" for HF than for He.
(c) The "b" factor in the van der Waals equation should be larger for He than for Cl_2.
(d) Gases approach their liquefaction points as temperature decreases and as pressure increases.
(e) Both "a" and "b" of the van der Waals equation have values of zero for an ideal gas.

14. About surface tension, which statements are true?

(a) The intermolecular interactions among the liquid molecules are responsible for the phenomenon of surface tension
(b) The molecules at the surface do not have other molecules on all sides of them and therefore are pulled inwards, which creates internal pressure and forces liquid surfaces to contract to the minimal area
(c) Surface tension can also be thought of as the amount of energy required to increase the surface area of a liquid
(d) Surface tension is not related to the capillary action.
(e) From the energy point of view, molecules in the surface area are in the lower energy state than molecules in the interior of a liquid.

15. About proteins, which statements are true?

(a) The primary structure is the order of the amino acids, which is crucial to the protein's biological function.
(b) Factors that might affect the tertiary structure of a protein include hydrogen bonds, electrostatic interactions, and hydrophobicity etc.
(c) α- helix and β- sheet are common secondary structures of proteins.
(d) Heat and pH change can lead to denatured proteins.
(e) The biological functions of proteins are not affected by their tertiary structure.

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Part II. Non-choice (70%)

1. (10 %) For the reaction of $2NO + H_2 \rightarrow N_2O + H_2O$, the following mechanism has been proposed :

$$2NO \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} N_2O_2$$

$$N_2O_2 + H_2 \xrightarrow{k_2} N_2O + H_2O$$

(1) Apply steady-state approximation to determine $[N_2O_2]$. (3%)

(2) Express the reaction rate in terms of [NO] and $[H_2]$. (3%)

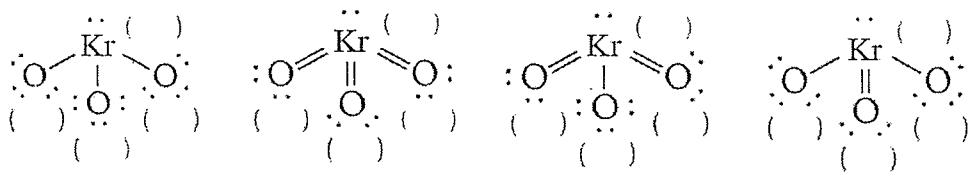
(3) If under high concentration of H_2, what is the overall reaction order? Which elementary step is the rate determining step? (2%)

(4) If under low concentration of H_2, what is the overall reaction order? Which elementary step is the rate determining step? (2%)

2. (10%) Following are four of possible Lewis structures for KrO_3.

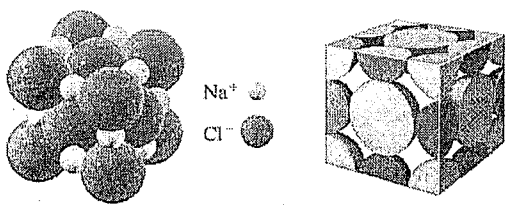
(1) Determine the formal charge of each atom in these four Lewis structures. (8 %)

A. B. C. D.



(2) Which Lewis structure is the most likely structure for XeO_3 (A-D)? (2 %)

3. (10%) For sodium chloride ionic crystal, Na^+ and Cl^- have ionic radius of 1.02 and 1.81 Å, respectively



(a) How many Cl^- ions surround a Na^+ ion? (2%)

(b) What is the edge length of each unit cell? (2 %)

(c) What is the shortest distance between two Na^+ ions? (3 %)

(d) What is the space between two nearest Cl^- ions? (3 %)

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國立中山大學 103 學年度碩士暨碩士專班招生考試試題

科目名稱：普通化學【醫科所碩士班選考】　　題號：428004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

4. (10 %) The treatment of a particle in a 1-D box can be extended to a 2-D box of length *a* in the x direction and width *b* in the y direction, yielding the following expression for energy:

$$E = \frac{h^2}{8m}\left(\frac{n_x^2}{a^2} + \frac{n_y^2}{b^2}\right)$$

The two quantum number, n_x and n_y can assume only integer values. Consider an electron confined to a 2-D box that is 9 nm in the x direction and 3 nm in the y direction.

(1) What are the quantum numbers for the first three allowed energy levels? (5%)

(2) Calculate the wavelength of light necessary to excite an electron from the ground state to the second excited state. (5%)

5. (10%) An electrochemical cell is constructed at 25 °C as follows: One half-cell consists of the Cl_2/Cl^- with a reduction potential of $E^o = +1.360$ V, and the other half-cell involves the $MnO4^-/Mn^{2+}$ in acidic solution with a reduction potential of $E^o = +1.507$ V.

(1) Write down the overall reaction for this electrochemical cell and determine its standard potential (3 %)

(2) What is the standard Gibbs free energy change, $\triangle G^o$? (3 %)

(3) Calculate the equilibrium constant K at 25°C (4 %)

6. (10%) For the following first-order rearrangement reaction,

$$CH_3NC \rightarrow CH_3CN$$

it was found that it has a frequency factor $A = 3.98 \times 10^{13}\ s^{-1}$, and activation energy $E_a = 160$ kJ/mol.

(1) Calculate the value of the specific rate constant at room temperature, 25 °C (4 %)
(2) Calculate the value of the specific rate constant at 115 °C (3 %)
(3) Calculate the half-life of the reaction at 25 °C (3 %)

7. (10%) Solid $Pb(NO_3)_2$ is added to a solution that is 0.03 M each in Na_2CO_3, Na_2SO_4, and NaOH.

(1) Write down the sequence of precipitation of $PbCO_3$, $PbSO_4$ and $Pb(OH)_2$
Ksp of $PbCO_3$, $PbSO_4$ and $Pb(OH)_2$ is 1.5×10^{-13} and 1.8×10^{-8} and 2.8×10^{-16} respectively (3%)

(2) When $PbSO_4$ begins to precipitate, calculate the concentration of $[CO_3^{2-}]$ (3%)

(3) When $PbSO_4$ begins to precipitate, calculate the percentage of OH^- that have precipitated (4%)

◙ Some of the following values and equations may be useful

Speed of light = 3.00×10^8 m/s

Planck's constant = 6.63×10^{-34} J•s

國立中山大學103學年度碩士暨碩士專班招生考試試題

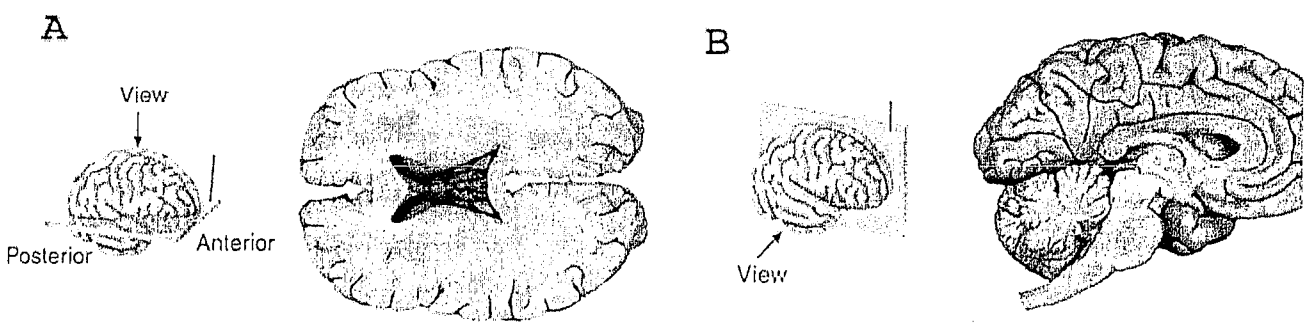
科目名稱：解剖學【醫科所碩士班選考】　　題號：428006

※本科目依簡章規定「不可以」使用計算機　　

請於答案卷依題目順序作答，並標明題號。不可於試題紙作答。

1. 請舉出一種神經追蹤劑並簡述它的功能。(5 %)

2. 根據圖一的大腦切片圖。請說明圖 A 與圖 B 分別為何種方位的切片。(10 %)

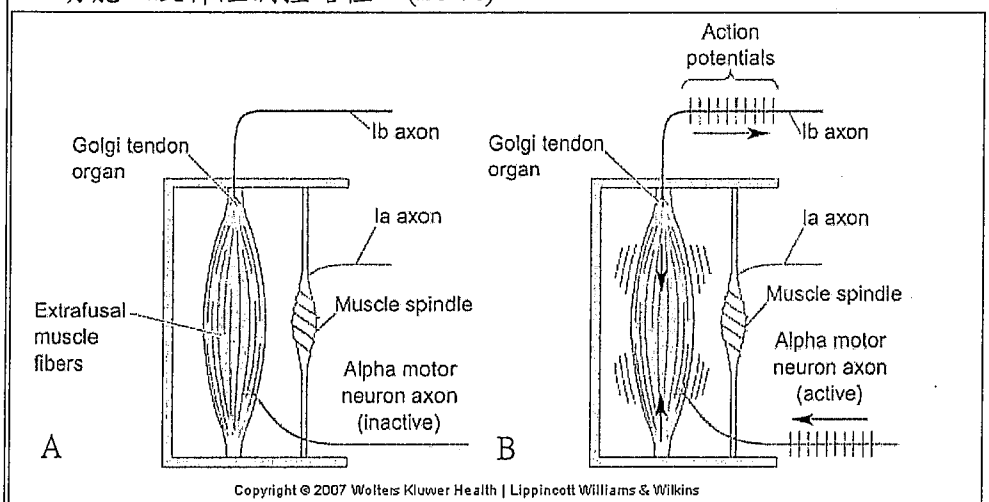


圖一、大腦解剖圖。

3. 請照順序列出血液由左心室回到右心房的循環路徑中會經過哪些心臟部位與血管組織。(10 %)

4. 請說明並比較電腦斷層(computed tomography)、核磁共振(magnetic resonance imaging)與正質子攝影(positron emission tomography)三種造影技術的原理與用途。(15 %)

5. 圖二為肌肉收縮時肌梭(muscle spindle)與肌腱(tendon)的功能。請根據下圖說明這兩種組織的功能以及神經調控路徑。(20 %)



圖二、肌梭與肌腱於運動神經元靜止(A)與活化(B)時的調控。

6. A. 請問哺乳類中主要負責吸氣的肌肉為哪一塊肌肉？(5 %)
   B. 承上題。這塊肌肉的組成是屬於骨骼肌、平滑肌或是心肌類型？(5 %)
   C. 承上題。請問這塊肌肉是受到自主神經或是體神經調控？(5 %)

7. 請由化學(chemical)、分子(molecular)、組織(tissue)與器官(organ)的層次說明"呼吸系統"的解剖學架構。(25 %)

國立中山大學 103 學年度碩士暨碩士專班招生考試試題

科目名稱：電子學【醫科所碩士班選考】　　題號：428007

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　共 3 頁

總分 100 分，請在答案紙上依題號順序作答。

1. (15%) Figure 1 shows a circuit for charging a 12-V battery. If v_s is a sinusoid with 24-V peak amplitude, find the fraction of each cycle during which the diode conducts. Also find the peak value of the diode current and the maximum reverse-bias voltage that appears across the diode.

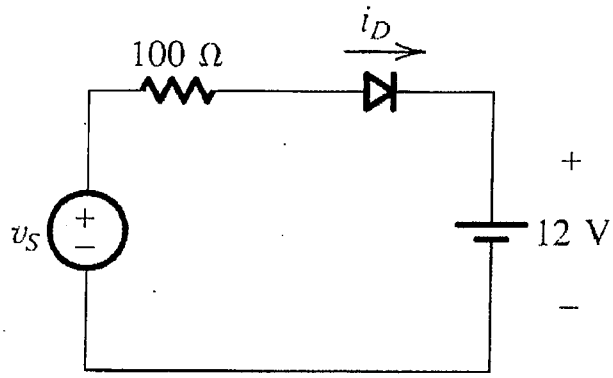


Figure 1.

2. (15%) Analyze the transistor amplifier shown in Figure 2 with dc analysis and small-signal model to determine its voltage gain. Assume the common-emitter current gain β=100.

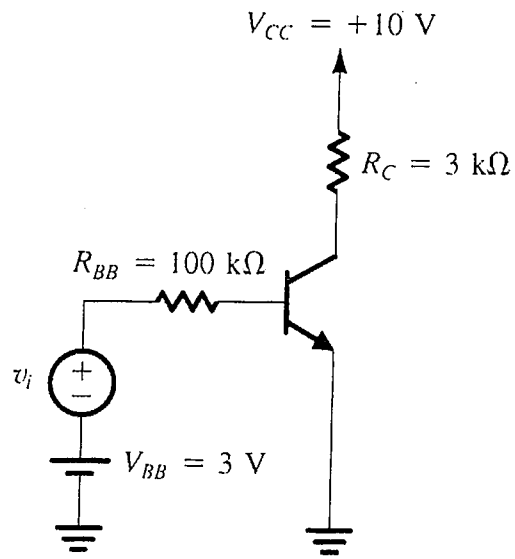


Figure 2.

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3. (20%) Design the circuit in Figure 3 to obtain a current I_D of 0.4 mA. Find the value required for R and find the dc voltage V_D. Let the NMOS transistor have $V_t = 2$ V, $\mu_n C_{ox} = 20\ \mu A/V^2$, $L = 10$ μm, and $W = 100$ μm. Neglect the channel-length modulation effect (that is, assume $\lambda = 0$).

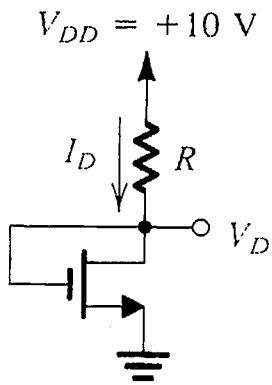
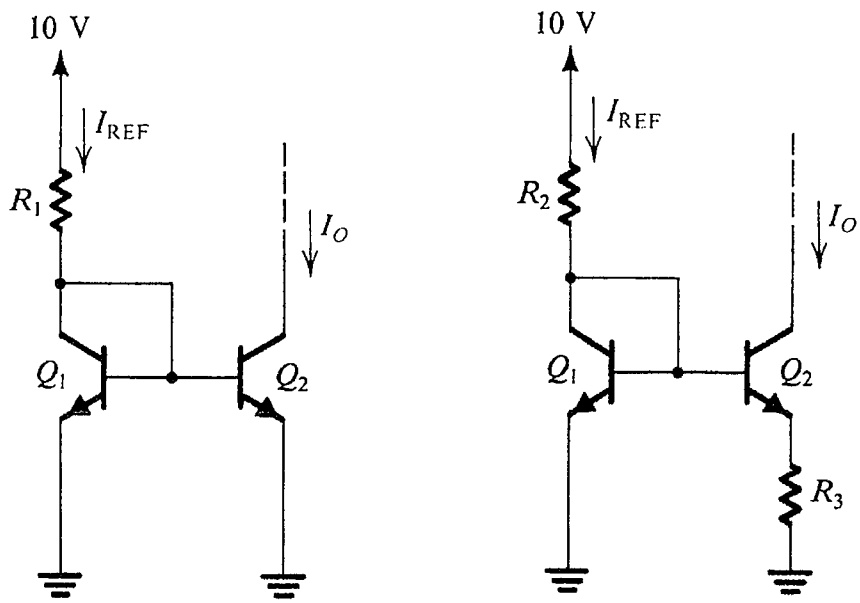


Figure 3.

4. (25%) Figure 4 shows two circuits: (a) and (b), for generating a constant current I_O = 10 μA. Determine the values of the required resistors assuming that V_{BE} is 0.7 V at a current of 1 mA and neglecting the effect of finite β. (Hint: apply I_{REF} = 10 μA for circuit (a) and I_{REF} = 1 mA for circuit (b).)



(a) (b)

Figure 4.

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5. (25%) Select appropriate values for the coupling capacitors C_{C1} and C_{C2} and the bypass capacitor C_s of the amplifier in Figure 5, so that the low-frequency response will be dominated by a pole at 100 Hz and that the nearest pole or zero will be at least a decade away. Also, determine the midband gain. Let $V_{DD} = 20$ V, $R = 100$ kΩ, $R_{G1} = 1.4$ MΩ, $R_{G2} = 0.6$ MΩ, $R_S = 3.5$ kΩ, $R_D = 5$ kΩ, $r_o = \infty$, $R_L = 10$ kΩ, the transconductance at this operating point $g_m = 4$ mA/V.

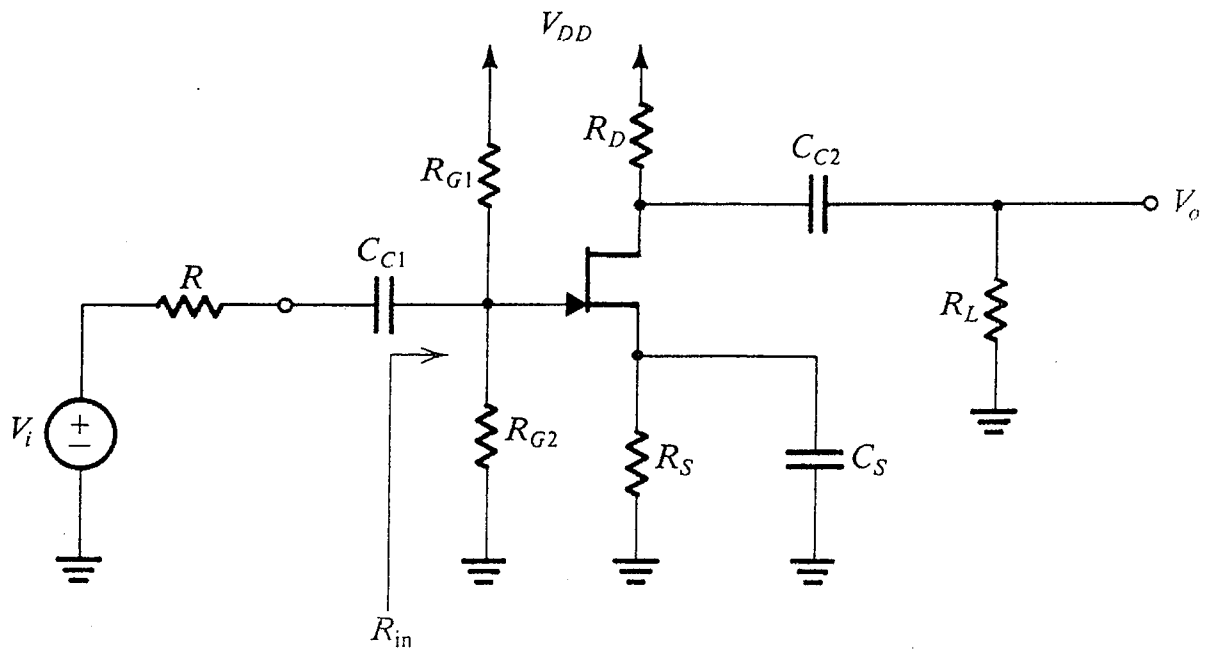

Figure 5.