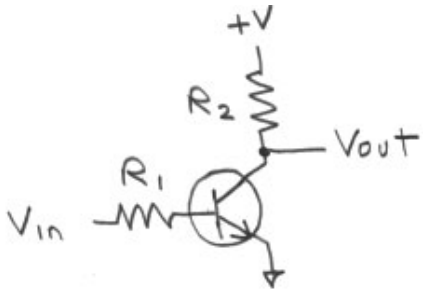
BioE 1310 - Review Nonlinear Systems and Sensors 3/20/2010

Instructions: On the Answer Sheet, enter your 2-digit ID number (with a leading 0 if needed) in the boxes of the ID section. *Fill in the corresponding numbered circles.* Answer each of the numbered questions by filling in the corresponding circles in the numbered question section. Print your name in the space at the bottom of the answer sheet. Sign here stating that you have neither given nor received help.

_____

your signature

1. If $R_1 = 200\text{K}\Omega$, $R_2 = 1\text{K}\Omega$, $V_{in} = 5\text{V}$, $+V = 10\text{V}$, with a $\beta = 150$ for the transistor, and ignoring the base-emitter voltage drop, what voltage would you expect at V_{out}?



A. Cannot be determined.

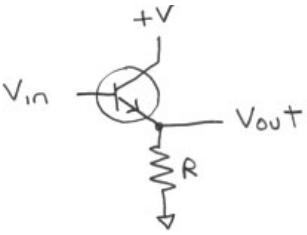
B. 6.25V

C. 3.75V

D. 2.75V

E. 5V

2. If $R = 1\text{K}\Omega$, $V_{in} = 2.5\text{V}$, $\beta = 150$, and the base-emitter voltage drop is 0.5V, what would you expect the current through R to be?



A. 0.3A

B. 375mA

C. 2mA

D. 0.2A

E. 2.5mA

3. Which of the following is (are) true about the photo-resistor used in our lab.

I - It is constructed of cadmium-sulfide.
II - Its resistance goes from very high in total darkness to much lower in bright light.
III - It is a polar device, and therefore must be inserted in the proper oreintation.

A. I

B. I and II

C. I and III

D. I, II and III

E. II and III

4. A thermistor differs from a standard resistor in that

A. A thermistor, unlike a standard resistor, has a non-linear relationship between current and voltage.

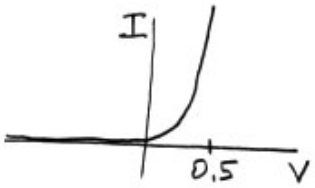
B. A thermistor has an imaginary impedance whereas the impedance of a standard resistance is real.

C. None of the other answers is true.

D. A thermistor demonstrates an intentionally poor constancy of resistance with change in temperature.

E. A thermistor's behavior depends on the direction of current through it.

5. Which of the following is (are) true about the graph below.



I - It shows that current flows when the diode if forward-biased but not when reverse-biased.
II - It shows that the diode can be safely attached to 1V in either orientation (forward- or reverse-biased).
III - It shows that the diode is a linear device.
IV - It shows that over a wide range of currents the voltage across the forward-biased diode is approximately 0.5V

A. I, II, and IV

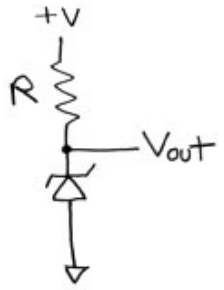
B. I, II and III

C. All of them.

D. I and III

E. I and IV

6. Which of the following is (are) true about the circuit below, given that $R = 1000\Omega$, $+V = 5$V, and the zener diode has a reverse breakdown voltage of 3V.



I - The current through the resistor is 3mA.
II - The zener diode is back-biased.
III - No current flows through the resistor.
IV - $V_{out} = 3V$

A. I, II and IV

B. II and IV

C. II and III

D. I, II, and III

E. II, III, and IV

7. A Zener diode can best be described as

A. a diode that has an extremely high reverse breakdown voltage, such that the breakdown voltage is never reached in practice.

B. a diode that exhibits completely linear behavior in both the forward and reverse biased condition, and thus obeys Ohm's law.

C. a component with three wires coming out of it.

D. a diode that is actually primarily used as an inductor.

E. a diode whose reverse breakdown voltage is used on purpose to provide a known and stable voltage, by maintaining that diode in the reverse-biased condition.

8. Which of the following are typical applications for diodes?

I - Peak Detector, to find the peak voltage over a time period.
II - Logical operations such as the Boolean OR operation.
III - Rectification (turning AC into DC).

A. I, II, and III

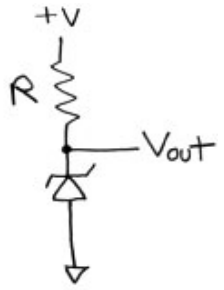
B. Only I

C. I and II

D. I and III

E. II and III

9. Which of the following is (are) true about the circuit below, given that R=10,000 Ω, $+V = 7$ V, and the zener diode has a reverse breakdown voltage of 4.2 V. Assume there is no current drawn from the output.



I - The voltage drop across the diode is about half a volt.
II - The current through the resistor is 280 μA.
III - The zener diode is back-biased.
IV - $V_{out} = 3.7V$

A. I, II, and IV

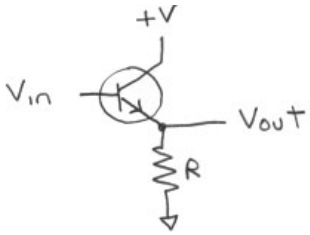
B. I, II and III

C. I, III and IV

D. II and III

E. II, III, and IV

10. If $R = 10\text{K}\Omega$, $V_{in} = 2.5\text{V}$, $\beta = 100$, and the base-emitter voltage drop is 0.5V, what would you expect the current through R to be?



A. 25 mA

B. No current will pass through the resistor.

C. 0.25mA

D. 0.2 mA

E. 20 mA

11. Which of the following is (are) linear components?

I - Capacitor.
II - Diode.
III - Resistor.

A. I and III

B. I and II

C. I, II, and III

D. III

E. II and III

12. The following are true about bipolar transistors *except*

A. They exhibit a voltage drop between the base and emitter, similar to that of a forward-biased diode, of about 0.5-0.7 volt.

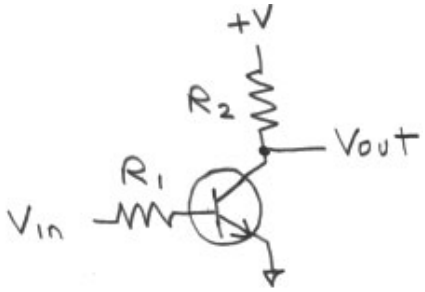
B. They consist of regions of semiconductor material (generally silicon), with some with some regions having extra electrons and some having extra "holes".

C. They can generally be modeled to have infinite input impedance and zero output impedance.

D. They are inherently nonlinear devices.

E. When properly biased, the collector current I_C and the base current I_B are related by an approximately constant proportion, β.

13. If $R_1 = 100\ K\Omega$, $R_2 = 2\ \mathrm{K}\Omega$, $V_{in} = 2.5$ V, $+V = 10$ V, with a $\beta = 100$ for the transistor, and a base-emitter voltage drop of 0.5 V, what voltage would you expect at V_{out}?



A. 2 V

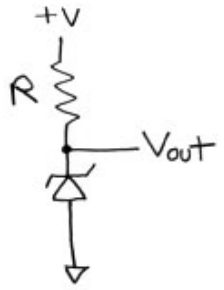
B. 4 V

C. 6 V

D. 0 V

E. 5 V

14. Which of the following is (are) true about the circuit below, given that R = 5000 Ω, $+V$ = 10 V, and the zener diode has a reverse breakdown voltage of 5 V.



I - The current through the resistor is 1 mA.
II - No current can flow through the zener diode.
III - V_{out} = 5 V.

A. I and III

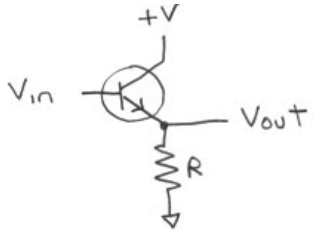
B. I and II

C. only III

D. II and III

E. I, II, and III

15. If $R = 10\Omega$, $\beta = 100$, the current through R is 50mA, and the base-emitter voltage drop is 0.5V, what would you expect V_{in} to be? (notice we are asking for the *input* voltage!)



A. 5 V

B. 5.5 V

C. 1 V

D. 0.5 V

E. 0 V

16. Which of the following is (are) true about the photo-resistor used in our lab.

I - It is constructed of cadmium-sulfide.
II - It stands out among types of photo detectors for being fast and extremely sensitive.
III - Its resistance goes from very high in total darkness to much lower in bright light.

A. I, II and III

B. I and III

C. I and II

D. I

E. II and III

17. Which of the following is (are) true about the graph of the current vs. voltage for a diode, below.

I - It shows that the diode acts like a perfect switch that is closed when the diode is forward-biased but open when it is reverse-biased.
II - It shows that the diode could suffer large currents if attached to 1V in the forward-biased condition.
III - It shows that over a wide range of currents the voltage across the forward-biased diode is approximately 0.5V

A. II and III

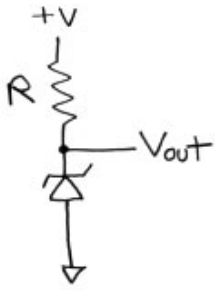
B. None of the other answers is correct.

C. I and III

D. I, II, and III

E. I and II

18. Which of the following is (are) true about the circuit below, given that $R = 100\Omega$, $+V = 6$V, and the zener diode has a reverse breakdown voltage of 2V.



I - The current through the resistor is 40mA.
II - The zener diode is forward-biased.
III - The voltage $V_{out} = 2V$

A. I and III

B. I, II, and III

C. only II

D. II and III

E. I and II

19. The following are true about bipolar transistors *except*, or all of the others are true.

A. When properly biased, the collector current I_C and the base current I_B are related by an approximately constant proportion, β.

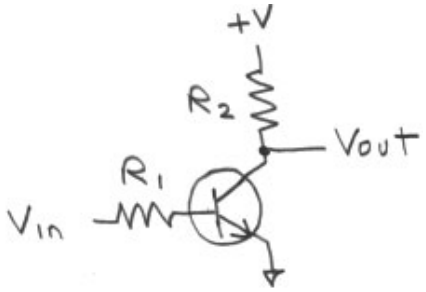
B. They consist of regions of semiconductor material (generally silicon), with some regions having extra electrons and some having extra "holes".

C. They exhibit a voltage drop between the base and emitter, similar to that of a forward-biased diode, of about 0.5-0.7 volt.

D. All of the others are true.

E. For NPN transistors (the kind we used in the lab) they can be modeled as two diodes back to back (with their anodes connected).

20. If $R_1 = 100\ K\Omega$, $R_2 = 2$ KΩ, $V_{in} = 2.5$ V, $+V = 11$ V, with a $\beta = 100$ for the transistor, and a base-emitter voltage drop of 0.5 V, what voltage would you expect at V_{out}?



A. 8 V

B. 5 V

C. 7 V

D. 6 V

E. 4 V

21. A thermistor differs from a standard resistor in that

A. A thermistor's behavior depends on the direction of current through it.

B. A thermistor demonstrates an intentional variation of resistance with temperature, and can be manufactured to have either a positive or a negative temperature coefficient.

C. A thermistor is a transistor that controls the flow of heat rather than electrical current.

D. A thermistor, unlike a standard resistor, is designed to generate heat when a current is passed through it.

E. A thermistor has an imaginary impedance whereas the impedance of a standard resistance is real.

22. A Zener diode can best be described as

A. a diode that has an extremely high reverse breakdown voltage, such that the breakdown voltage is never reached in practice.

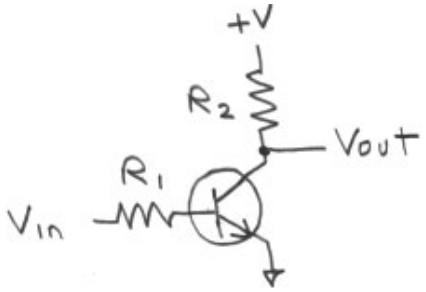
B. a transistor with extremely high input impedance.

C. a diode that is actually primarily used as an capacitor.

D. a diode that exhibits identical behavior in the forward and reverse biased condition.

E. a diode whose reverse breakdown voltage provides a known and stable reference voltage when reverse-biased.

23. If $R_1 = 100\ K\Omega$, $R_2 = 2$ KΩ, $V_{in} = 3$ V, $+V = 10$ V, with a $\beta = 100$ for the transistor, and a base-emitter voltage drop of 0.5 V, what voltage would you expect at V_{out}?



A. 0 V

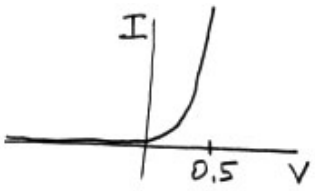
B. 6 V

C. 2 V

D. None of the other answers is correct.

E. 5 V

24. Which of the following is (are) true about the graph below.



I - It shows that current flows when the diode is forward-biased but not when reverse-biased.
II - It shows that the diode cannot be attached to 1V in the forward-biased direction without risking destroying it.
III - It shows that the diode is a non-linear device.

A. II and III

B. I

C. I and II

D. I, II and III

E. I and III

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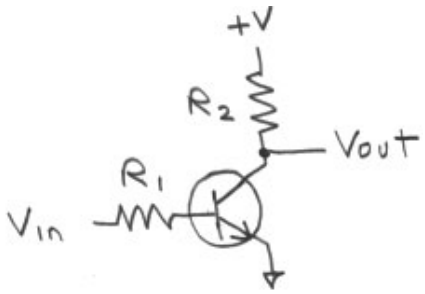
BioE 1310 - Review Nonlinear Systems and Sensors 3/20/2010
Answer Sheet - Correct answer is A for all questions

1. If $R_1 = 200\text{K}\Omega$, $R_2 = 1\text{K}\Omega$, $V_{in} = 5\text{V}$, $+V = 10\text{V}$, with a $\beta = 150$ for the transistor, and ignoring the base-emitter voltage drop, what voltage would you expect at V_{out}?



A. 6.25V

B. 5V

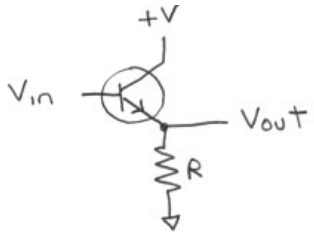
C. 2.75V

D. 3.75V

E. Cannot be determined.

Explanation: $V_{out} = (10 - 150 \times 1000\Omega(5\text{V}/200\text{K}\Omega))$
[*circuits0030.mcq*]

2. If $R = 1\text{K}\Omega$, $V_{in} = 2.5\text{V}$, $\beta = 150$, and the base-emitter voltage drop is 0.5V, what would you expect the current through R to be?



A. 2mA

B. 2.5mA

C. 0.3A

D. 375mA

E. 0.2A

Explanation: Current $= \frac{V_{in} - 0.5\text{V}}{R}$; β is not needed.
[*circuits0032.mcq*]

3. Which of the following is (are) true about the photo-resistor used in our lab.

I - It is constructed of cadmium-sulfide.
II - Its resistance goes from very high in total darkness to much lower in bright light.
III - It is a polar device, and therefore must be inserted in the proper oreintation.

A. I and II

B. I, II and III

C. II and III

D. I

E. I and III

Explanation: It is generally the (-) input of the op amp. III is nonsense.
[*circuits0033.mcq*]

4. A thermistor differs from a standard resistor in that

A. A thermistor demonstrates an intentionally poor constancy of resistance with change in temperature.

B. A thermistor, unlike a standard resistor, has a non-linear relationship between current and voltage.

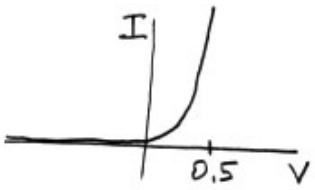
C. A thermistor's behavior depends on the direction of current through it.

D. A thermistor has an imaginary impedance whereas the impedance of a standard resistance is real.

E. None of the other answers is true.

Explanation: Thermistors change resistance intentionally with temperature.
[*circuits0034.mcq*]

5. Which of the following is (are) true about the graph below.



I - It shows that current flows when the diode if forward-biased but not when reverse-biased.
II - It shows that the diode can be safely attached to 1V in either orientation (forward- or reverse-biased).
III - It shows that the diode is a linear device.
IV - It shows that over a wide range of currents the voltage across the forward-biased diode is approximately 0.5V

A. I and IV

B. I, II and III

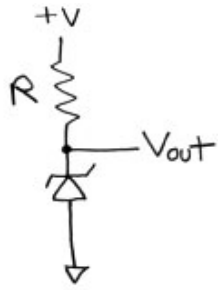
C. I, II, and IV

D. I and III

E. All of them.

Explanation: The diode is clearly not linear (like a resistor is), and the current approaches ∞ mathematically as the voltage goes over 0.5V.
[*circuits0035.mcq*]

6. Which of the following is (are) true about the circuit below, given that $R = 1000\Omega$, $+V = 5$V, and the zener diode has a reverse breakdown voltage of 3V.



I - The current through the resistor is 3mA.
II - The zener diode is back-biased.
III - No current flows through the resistor.
IV - $V_{out} = 3V$

A. II and IV

B. I, II and IV

C. II, III, and IV

D. II and III

E. I, II, and III

Explanation: The voltage across the back-biased diode is 3V. The voltage across the resistor is 5V - 3V = 2V; The current through the resistor is 2 mA.
[*circuits0038.mcq*]

7. A Zener diode can best be described as

A. a diode whose reverse breakdown voltage is used on purpose to provide a known and stable voltage, by maintaining that diode in the reverse-biased condition.

B. a component with three wires coming out of it.

C. a diode that is actually primarily used as an inductor.

D. a diode that exhibits completely linear behavior in both the forward and reverse biased condition, and thus obeys Ohm's law.

E. a diode that has an extremely high reverse breakdown voltage, such that the breakdown voltage is never reached in practice.

Explanation: A zener diode is one that intentionally has a known, and usually relatively low, breakdown voltage, which is used by reverse-biasing the diode.
[*circuits0092.mcq*]

8. Which of the following are typical applications for diodes?

I - Peak Detector, to find the peak voltage over a time period.
II - Logical operations such as the Boolean OR operation.
III - Rectification (turning AC into DC).

A. I, II, and III

B. I and III

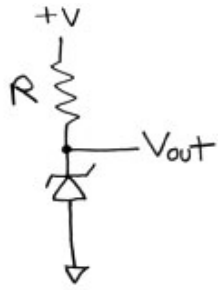
C. II and III

D. I and II

E. Only I

Explanation: All three are uses for diodes.
[*circuits0094.mcq*]

9. Which of the following is (are) true about the circuit below, given that R=10,000 Ω, $+V$ = 7 V, and the zener diode has a reverse breakdown voltage of 4.2 V. Assume there is no current drawn from the output.



I - The voltage drop across the diode is about half a volt.
II - The current through the resistor is 280 μA.
III - The zener diode is back-biased.
IV - $V_{out} = 3.7V$

A. II and III

B. I, III and IV

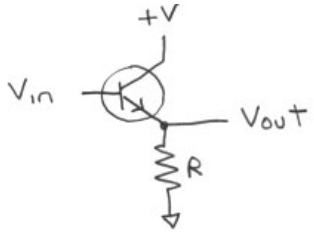
C. II, III, and IV

D. I, II and III

E. I, II, and IV

Explanation: The voltage across the back-biased diode is 4.2V. The voltage across the resistor is 7 V - 4.2 V = 2.8 V; The current through the resistor is 2.8 280 μA.
[*circuits0104.mcq*]

10. If $R = 10\text{K}\Omega$, $V_{in} = 2.5\text{V}$, $\beta = 100$, and the base-emitter voltage drop is 0.5V, what would you expect the current through R to be?



A. 0.2 mA

B. 0.25mA

C. 20 mA

D. 25 mA

E. No current will pass through the resistor.

Explanation: Current = $\frac{V_{in}-0.5\text{V}}{R}$; β is not needed.
[*circuits0106.mcq*]

11. Which of the following is (are) linear components?

I - Capacitor.
II - Diode.
III - Resistor.

A. I and III

B. I and II

C. II and III

D. I, II, and III

E. III

Explanation: Resistors are linear. Capacitors are linear for A.C. and are thus considered linear devices. Diodes are not linear.
[*circuits0108.mcq*]

12. The following are true about bipolar transistors *except*

A. They can generally be modeled to have infinite input impedance and zero output impedance.

B. They consist of regions of semiconductor material (generally silicon), with some with some regions having extra electrons and some having extra "holes".

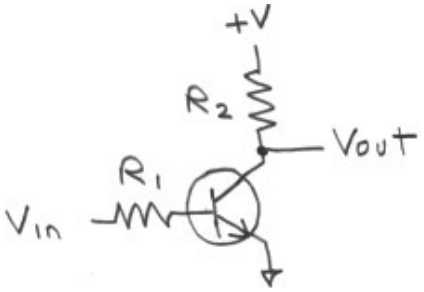
C. When properly biased, the collector current I_C and the base current I_B are related by an approximately constant proportion, β.

D. They are inherently nonlinear devices.

E. They exhibit a voltage drop between the base and emitter, similar to that of a forward-biased diode, of about 0.5-0.7 volt.

Explanation: There is a definite base current, so the input impedance is not zero. Also, since the collector current is relatively insensitive to voltage, they have a high, not low, output impedance (i.e., they act like a current source.
[*circuits0109.mcq*]

13. If $R_1 = 100\ K\Omega$, $R_2 = 2$ KΩ, $V_{in} = 2.5$ V, $+V = 10$ V, with a $\beta = 100$ for the transistor, and a base-emitter voltage drop of 0.5 V, what voltage would you expect at V_{out}?



A. 6 V

B. 5 V

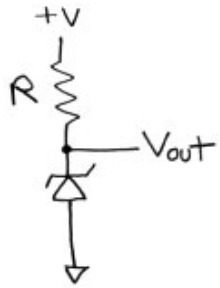
C. 4 V

D. 2 V

E. 0 V

Explanation: The Voltage across R_1 is 2.5 V − 0.5 V, so the base current is 2V/100 $K\Omega = 20\ \mu$A. Collector current is thus 20 μA × 100 = 2 mA. Voltage across $R_2 = 2$ mA × 2 K$\Omega = 4$V. $V_{out} = 10$ V − 4 V = 6 V
[*circuits0117.mcq*]

14. Which of the following is (are) true about the circuit below, given that R = 5000 Ω, $+V = 10$ V, and the zener diode has a reverse breakdown voltage of 5 V.



I - The current through the resistor is 1 mA.
II - No current can flow through the zener diode.
III - $V_{out} = 5$ V.

A. I and III

B. I and II

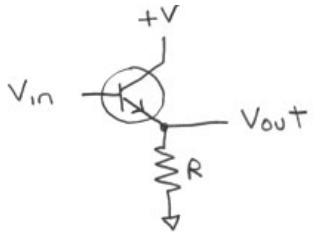
C. II and III

D. only III

E. I, II, and III

Explanation: The voltage across the back-biased zener diode is 5 V. The voltage across the resistor is 10 V − 5 V = 5 V; The current through the resistor is 1 mA, and that same current must be running through the zener (at least it will when there is no current flowing to the output).
[*circuits0121.mcq*]

15. If $R = 10\Omega$, $\beta = 100$, the current through R is 50mA, and the base-emitter voltage drop is 0.5V, what would you expect V_{in} to be? (notice we are asking for the *input* voltage!)



A. 1 V

B. 0.5 V

C. 5.5 V

D. 0 V

E. 5 V

Explanation: This is an emitter follower. $V_{out} = V_{in} - 0.5\text{V}$; β is not needed.
[*circuits0154.mcq*]

16. Which of the following is (are) true about the photo-resistor used in our lab.

I - It is constructed of cadmium-sulfide.
II - It stands out among types of photo detectors for being fast and extremely sensitive.
III - Its resistance goes from very high in total darkness to much lower in bright light.

A. I and III

B. I, II and III

C. II and III

D. I

E. I and II

Explanation: II is not true. Photodiodes and phototransistors are faster and more sensitive.
[*circuits0155.mcq*]

17. Which of the following is (are) true about the graph of the current vs. voltage for a diode, below.

I - It shows that the diode acts like a perfect switch that is closed when the diode is forward-biased but open when it is reverse-biased.
II - It shows that the diode could suffer large currents if attached to 1V in the forward-biased condition.
III - It shows that over a wide range of currents the voltage across the forward-biased diode is approximately 0.5V

A. II and III

B. I and III

C. I and II

D. I, II, and III

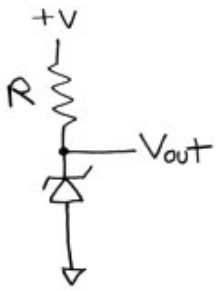
E. None of the other answers is correct.

Explanation: The current approaches ∞ mathematically as the voltage goes over 0.5V. It does not act as a perfect switch, because of the 0.5V forward biased drop.

Alternate acceptable answer: E

Errata: The word "suffer" in II is ambiguous, because it could be taken to mean that the diode could "put up with" large currents and survive, whereas what was meant was that it would be destroyed. So II could be false and therefore answer E is an acceptable alternate answer.
[*circuits0156.mcq*]

18. Which of the following is (are) true about the circuit below, given that $R = 100\Omega$, $+V = 6$V, and the zener diode has a reverse breakdown voltage of 2V.



I - The current through the resistor is 40mA.
II - The zener diode is forward-biased.
III - The voltage $V_{out} = 2V$

A. I and III

B. I and II

C. I, II, and III

D. II and III

E. only II

Explanation: The voltage across the back-biased diode is 2V. The voltage across the resistor is 6V - 2V = 4V; The current through the resistor therefore is 40 mA.
[*circuits0161.mcq*]

19. The following are true about bipolar transistors *except*, or all of the others are true.

A. All of the others are true.

B. They consist of regions of semiconductor material (generally silicon), with some regions having extra electrons and some having extra "holes".

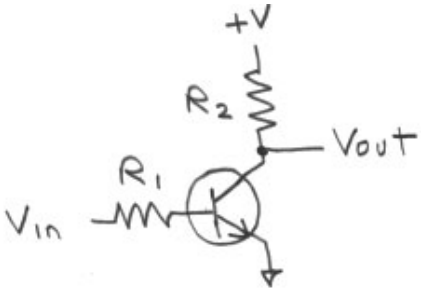
C. When properly biased, the collector current I_C and the base current I_B are related by an approximately constant proportion, β.

D. For NPN transistors (the kind we used in the lab) they can be modeled as two diodes back to back (with their anodes connected).

E. They exhibit a voltage drop between the base and emitter, similar to that of a forward-biased diode, of about 0.5-0.7 volt.

Explanation: All are true.
[*circuits0162.mcq*]

20. If $R_1 = 100\ K\Omega$, $R_2 = 2$ KΩ, $V_{in} = 2.5$ V, $+V = 11$ V, with a $\beta = 100$ for the transistor, and a base-emitter voltage drop of 0.5 V, what voltage would you expect at V_{out}?



A. 7 V

B. 5 V

C. 8 V

D. 6 V

E. 4 V

Explanation: The Voltage across R_1 is 2 V $-$ 0.5 V, so the base current is 2V/100 $K\Omega = 20\ \mu$A. Collector current is thus 20 μA $\times$ 100 = 2 mA. Voltage across $R_2 = 2$ mA $\times$ 2 K$\Omega = 4$V. $V_{out} = 11$ V $- 4$ V $= 7$ V
[*circuits0163.mcq*]

21. A thermistor differs from a standard resistor in that

A. A thermistor demonstrates an intentional variation of resistance with temperature, and can be manufactured to have either a positive or a negative temperature coefficient.

B. A thermistor, unlike a standard resistor, is designed to generate heat when a current is passed through it.

C. A thermistor's behavior depends on the direction of current through it.

D. A thermistor has an imaginary impedance whereas the impedance of a standard resistance is real.

E. A thermistor is a transistor that controls the flow of heat rather than electrical current.

Explanation: Thermistors change resistance intentionally with temperature. The one we used in the lab had a negative temperature coefficient. All transistors heat up when a current is passed through them, including thermistors, but that is not the purpose of a thermistor. The impedance of a thermistor is still real, it just varies. Answer E is silly.
[*circuits0164.mcq*]

22. A Zener diode can best be described as

A. a diode whose reverse breakdown voltage provides a known and stable reference voltage when reverse-biased.

B. a transistor with extremely high input impedance.

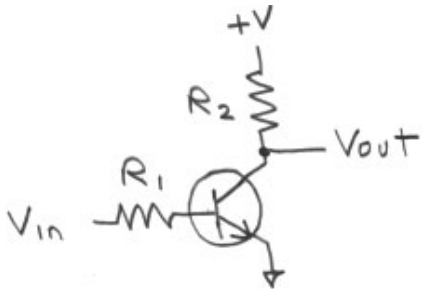
C. a diode that is actually primarily used as an capacitor.

D. a diode that exhibits identical behavior in the forward and reverse biased condition.

E. a diode that has an extremely high reverse breakdown voltage, such that the breakdown voltage is never reached in practice.

Explanation: A zener diode is one that intentionally has a known, and usually relatively low, breakdown voltage, which is used by reverse-biasing the diode.
[*circuits0165.mcq*]

23. If $R_1 = 100\ K\Omega$, $R_2 = 2$ KΩ, $V_{in} = 3$ V, $+V = 10$ V, with a $\beta = 100$ for the transistor, and a base-emitter voltage drop of 0.5 V, what voltage would you expect at V_{out}?



A. 5 V

B. 6 V

C. None of the other answers is correct.

D. 2 V

E. 0 V

Explanation: The Voltage across R_1 is 3 V $-$ 0.5 V, so the base current is 2.5V/100 $K\Omega = 25\ \mu$A. Collector current is thus 25 μA $\times$ 100 = 2.5 mA. Voltage across $R_2 = 2.5$ mA $\times$ 2 K$\Omega = 5$V. $V_{out} = 10$ V $-$ 5 V = 5 V
[*circuits0184.mcq*]

24. Which of the following is (are) true about the graph below.

I - It shows that current flows when the diode is forward-biased but not when reverse-biased.
II - It shows that the diode cannot be attached to 1V in the forward-biased direction without risking destroying it.
III - It shows that the diode is a non-linear device.

A. I, II and III

B. II and III

C. I and II

D. I and III

E. I

Explanation: The diode is clearly not linear (like a resistor is), and the current approaches ∞ mathematically as the voltage goes over 0.5V.
[*circuits0195.mcq*]