1. How many valence electrons does carbon have?

2. What is the ground-state electron configuration for Al?

3. Calculate the coordination numbers for each of the elements in CaF_2 from the following: r(Ca) = 0.197 nm, $r(Ca^{+2})$ = 0.106 nm, r(F) = 0.06 nm, $r(F^-)$ = 0.133 nm.

4. For a reaction that occurs with an activation energy of 50 kJ/mol, how much should the temperature be increased from room temperature (25 °C) to double the reaction rate?

5. Predict the most likely primary bond in SiC.

6. On the same plot, sketch two bond-energy curves for two materials characterized by a high melting point and by a low melting point. Label the axes and curves.

7. Briefly explain why nylons exhibit higher melting points than polyethylene (can be accomplished using 3 words).

8. How can a thermoplastic be converted into a thermoset (can be accomplished using 1 word)?

9. How many valence electrons does oxygen have?

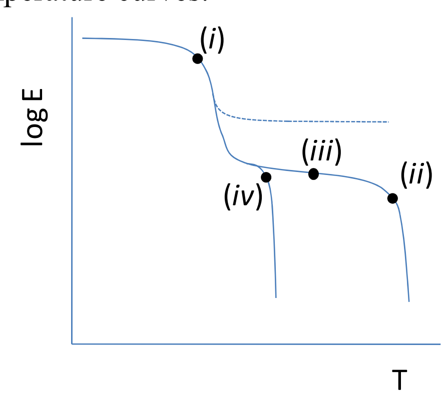
10. A metal tensile bar, 10-mm in diameter and 5-cm long, exhibits a yield strength of 400 MPa, an elastic modulus of 70 GPa, and an ultimate tensile strength of 500 MPa. What is the maximum load that this sample withstands during this test?

11. Sketch a plot of impact strength versus temperature for a material that exhibits a ductile-to-brittle transition. Clearly label axes.

12. What is the critical flaw size in micrometers for a ceramic sample (K_{Ic} = 2 MPa√m) subjected to a tensile stress of 1500 MPa if the stress intensity parameter is $K = 1.12\sigma(\pi a)^{1/2}$?

13. Calculate the maximum allowable stress that can be imposed on a titanium alloy strut with fracture toughness 44 MPa√m if it is known to contain a penny-shaped crack [$K = 2\sigma(a/\pi)^{1/2}$] of diameter 1.6 cm.

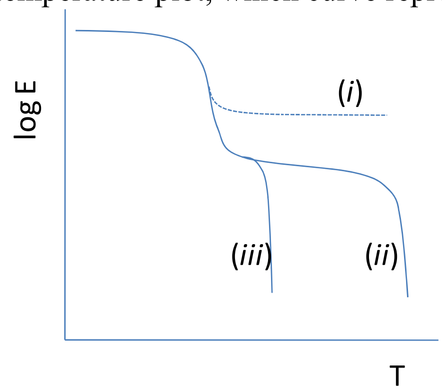
For the following modulus-temperature curves:



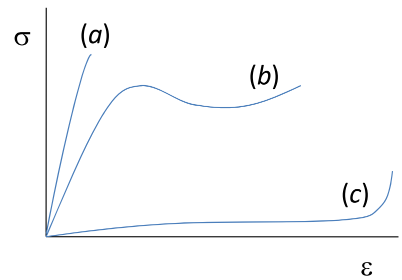
14. Which point or points represent the T_g on the curve above?

15. Which point or points represents the T_m on the curve above?

16. For the following modulus-temperature plot, which curve represents a crosslinked elastomer?



17. Which of the following stress-strain curves represents the behavior of an amorphous polymer below T_g?



18. A ceramic cylinder, 10-mm in diameter and 1-m long, is axially loaded with a force of 2000 N. Assuming the material is linear elastic with a modulus of 380 GPa, what is the elongation in μm?

19. To what value does the stress relax in a polymer fiber 20 minutes after loading to constant strain with a 20 kPa stress if the relaxation time is 1200 s?

20. What is the relaxation time of a polymer fiber that is stretched 25% and held if the initial tensile stress is 30 kPa and the stress after 10 minutes is 20 kPa?

21. How much clay (E = 200 GPa, d = 1.5 g/cm^3) must be blended into natural rubber (E = 20 MPa, d = 0.9 g/cm^3) to double its stiffness?

22. Calculate the strength in GPa of a synthetic biomaterial designed to replace damaged tendon if when fashioned into a cylindrical specimen with a 10 μm diameter it fails when a load of 10 g is suspended from its end.

23. Show a sketch of relaxation modulus versus time in a creep test.

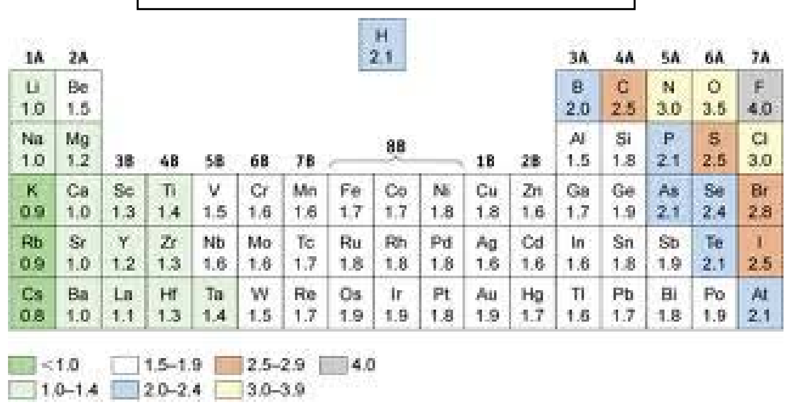
24. What is the deflection of a nylon specimen (E = 2.83 GPa) if a load of 5000 N is applied and it is 1-m long with a cross section of 1 cm by 1 cm?

25. For a material characterized by a stress intensity parameter $K = \sigma(\pi a)^{1/2}$, if a crack of length 2a doubles in length, how is the fracture strength changed and by what factor?

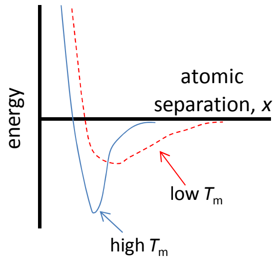
$\sigma(t) = \sigma_o exp(-t/\tau)$, $\sigma = F/A_0$, $\varepsilon = (l - l_o)/l_o$, $E = \sigma/\varepsilon$, $E = E_1V_1 + E_2V_2$, $Rate = C\exp(-Q/RT)$
R = 8.314 J/K mol, g = 9.8 m/s^2

Coordination number	Critical r/R value
2	0
3	0.155
4	0.225
6	0.414
8	0.732
12	1

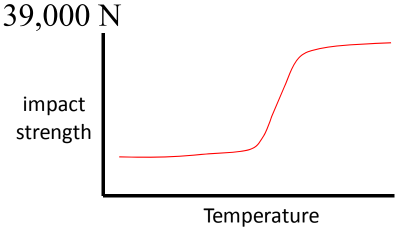
Electronegativity values



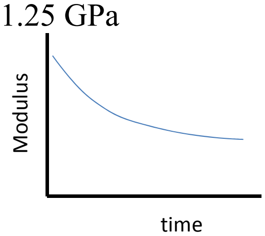
1. 4
2. $1s^2 2s^2 2p^6 3s^2 3p^1$
3. $CN(Ca^{+2}) = 8$, $CN(F^-) = 4$
4. 10 °C
5. covalent

6. 

7. stronger secondary bonding (i.e., hydrogen bonding)
8. crosslinking (or vulcanization)
9. 6
10. 39,000 N

11. 

12. 0.45 μm
13. 436 MPa
14. (i)
15. (ii) and (iv)
16. (i)
17. (a)
18. 67 μm
19. 7.4 kPa
20. 1480 s
21. volume fraction = .0001 (or .01%)
22. 1.25 GPa

23. 

24. 1.8×10^{-2} m
25. reduced by √2