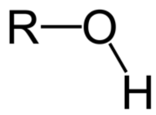
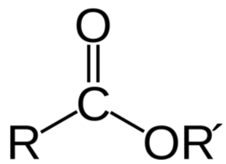
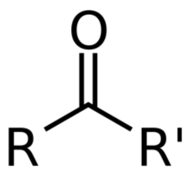
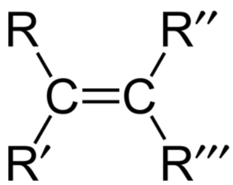
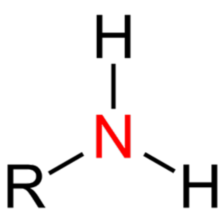
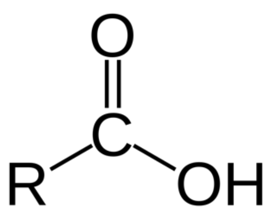
MATERIALS SCIENCE KEY

Part 1: Structure & Synthesis Topics (46 possible points)

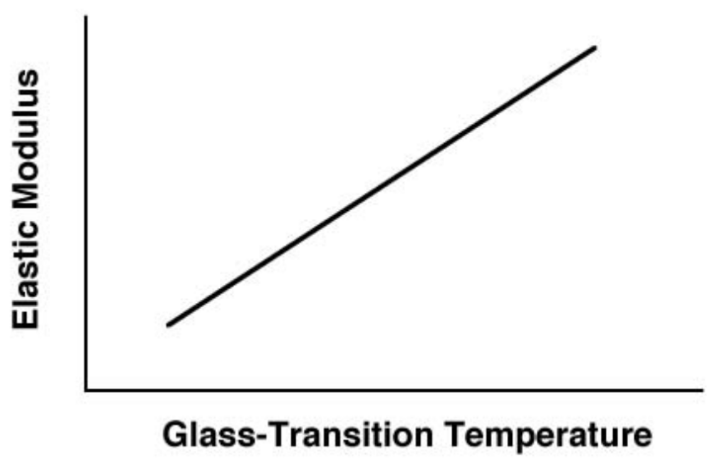
1.  **(2 points)**
2.  **(2 points)**
3.  **(2 points)**
4.  **(2 points)**
5.  **(2 points)**
6.  **(2 points)**
7. Ester (2) **(1 point)**, Ketone (3) **(1 point)**, Carboxylic Acid (6) **(1 point)**
8. Bifunctional monomers can bond to two other units in forming the 2-D chain-like molecular structure **(1 point)**; trifunctional monomers have three active bonds, from which a 3-D network structure results **(1 point)**
9. *Conformation* is the physical outline of a molecule, or molecule shape that can only be altered by rotation of chain atoms about single bonds **(1 point)**; *configuration* is the relative stereochemistry of adjacent chiral centers within a polymer, i.e. relative locations of side bonded atoms, R groups, or radicals **(1 point)**
10. Network **(1 point)**

11. Linear **(1 point)**
12. Crosslinked **(1 point)**
13. Network **(1 point)**
14. Branched **(1 point)**
15. Linear **(1 point)**
16. h **(1 point)**
17. d **(1 point)**
18. f **(1 point)**
19. a **(1 point)**
20. e **(1 point)**
21. b **(1 point)**
22. c **(1 point)**
23. i **(1 point)**
24. g **(1 point)**
25. j **(1 point)**
26. 1 (PETE) **(1 point)**
27. 6 (PS) **(1 point)**
28. 2 (HDPE) **(1 point)**
29. 7 (other) **(1 point)**
30. 4 (LDPE) **(1 point)**
31. *Thermoplasts* soften when heated (and eventually liquefy) and harden when cooled **(1 point)**. As temperature is raised, secondary bonding forces are diminished by increased molecular motion so that relative movement of adjacent chains is facilitated when stress is applied **(1 point)**. Most linear polymers and some branched structures with flexible chains are thermoplasts **(1 point)**. *Thermosets* become permanently hard when heat is applied and do not soften upon subsequent heating **(1 point)**. Covalent crosslinks form between adjacent molecular chains, anchoring the chains together to resist vibrational and rotational chain motions at high temperatures **(1 point)**. Most crosslinked and network polymers are thermosets **(1 point)**.

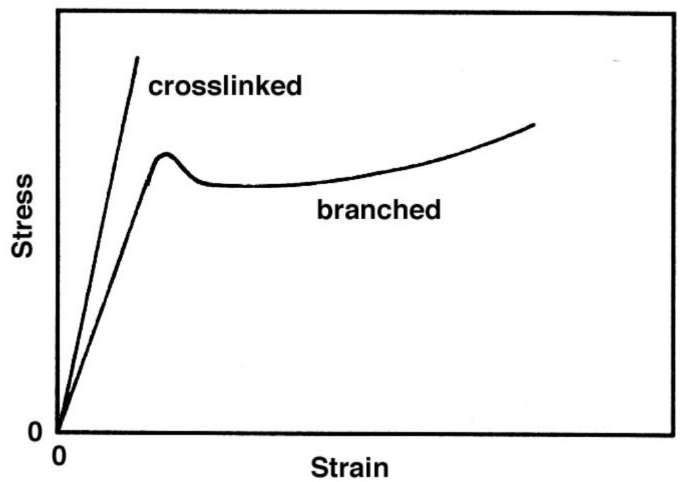
Part 2: Characterization, Performance, Processing, and Application Topics (29 possible points)

32. $M_n=\sum xM$; (0.05)(12,000 g/mol) + (0.16)(20,000 g/mol) + (0.24)(28,000 g/mol) + (0.28)(36,000 g/mol) + (0.20)(44,000 g/mol) + (0.07)(52,000 g/mol) = 33,040 g/mol **(1 point for equation setup, 1 point for correct answer)**
33. $M_w=\sum wM$; (0.02)(12,000 g/mol) + (0.10)(20,000 g/mol) + (0.20)(28,000 g/mol) + (0.30)(36,000 g/mol) + (0.27)(44,000 g/mol) + (0.11)(52,000 g/mol) = 36,240 g/mol **(1 point for equation setup, 1 point for correct answer)**
34. $n_n=M_n/m$; n_n = (33,040 g/mol)/(62.50 g/mol) = 528.64 → 529 (mer units) **(1 point for equation setup, 1 point for correct answer)**
35. $n_w=M_w/m$; 160 = (36,240 g/mol)/m = 226.50 g/mol **(1 point for equation setup, 1 point for correct answer)**
36. Plastic **(1 point)**
37. Yield point, or proportional limit **(1 point)**
38. Elastomers, or elastomeric **(1 point)**
39. Resilience **(1 point)**
40. Poisson's Ratio, or transverse strain **(1 point)**

41. Viscoelastic **(1 point)**
42. Increase **(1 point)**
43. Increase **(1 point)**
44. Decrease **(1 point)**
45. Increase **(1 point)**
46. Increase **(1 point)**
47. As molecular weight of a polymer increases (perhaps due to heavy side chains, or simply large chain length) it becomes increasingly difficult for all regions along adjacent chains to align so as to produce an ordered atomic array **(2 points for full explanation)**
48. $\%C=[D_c*(D_s-D_a)/D_s*(D_c-D_a)]*100$; %C = [0.98*(0.84-0.75)/0.84*(0.98-0.75)]*100 = 45.65217391 → 45.65% **(1 point for equation setup, 1 point for correct answer)**
49. **(1 point for correctly labeling axes, 1 point for drawing positive linear relationship)**



50. $TS = TS_\infty - A/M_n$; 107 MPa = TS_∞ - A/(40,000 g/mol), 170 MPa = TS_∞ - A/(60,000 g/mol) → TS_∞ = 296 MPa, A = $7.56*10^6$ MPa-g/mol → TS = 296 MPa - ($7.56*10^6$ MPa-g/mol) /(30,000 g/mol) = 44 MPa **(1 point for equation setup, 1 point for correct answer)**
51. The branched polyethylene will display normal plastic behavior, whereas the heavily crosslinked polyethylene will be stiffer, stronger, and more brittle. **(1 point for correct branched PE stress-strain curve, 1 point for correct crosslinked PE stress-strain curve)**


crosslinked
branched
Stress
Strain
0
0