Chem 1215 Practice Problems Comprehensive Final – Solutions

1. $cal = 1.30 \times 10^3\ kJ \times \frac{10^3\ J}{1\ kJ} \times \frac{1\ cal}{4.184\ J} = \boxed{3.11 \times 10^5\ cal}$

2. $d = \frac{mass}{vol} \Rightarrow V = \frac{mass}{d} = 22.3g \times \frac{mL}{0.842g} = \boxed{26.5\ mL}$

3. (a) H: nonmetal / none / maingroup
   (b) Zn: metal / none / transition metal
   (c) As: metalloid / none / main group
   (d) Mg: metal / alkaline earth metal / main group
   (e) He: nonmetal / noble gas / main group

4. F_2, Cl_2, Br_2, I_2

5. (a) HNO_3
   (b) H_2SO_4
   (c) $NaHCO_3$
   (d) $Ca(OH)_2$
   (e) $Fe_2(SO_4)_3$
   (f) NH_4ClO_4
   (g) $Mg_3(PO_4)_2$
   (h) Na_3PO_4
   (i) Cl_2O_7
   (j) P_4S_{10}
   (k) $KMnO_4$

6. (a) sodium carbonate
   (b) hydrofluoric acid
   (c) phosphoric acid
   (d) aluminum nitrite
   (e) sodium phosphite
   (f) lead (IV) oxide
   (g) sulfur trioxide
   (h) chromium (III) oxide
   (i) silver sulfate

7. (a) $2\ C_4H_{10} + 13\ O_2 \longrightarrow 8\ CO_2 + 10\ H_2O$

   (b) $3\ HNO_{3(aq)} + Al(OH)_{3(s)} \longrightarrow Al(NO_3)_{3(aq)} + 3\ H_2O_{(l)}$

   (c) $3\ Ca(NO_3)_{2\ (aq)} + 2\ K_3PO_{4\ (aq)} \rightarrow Ca_3(PO_4)_{2\ (s)} + 6\ KNO_{3\ (aq)}$

8. $2\,AgNO_3 + CaCl_2 \longrightarrow 2\,AgCl + Ca(NO_3)_2$

$$g\,AgNO_3 = 10.0\,g\,CaCl_2 \times \frac{1\,mol\,CaCl_2}{110.98\,g\,CaCl_2} \times \frac{2\,mol\,AgNO_3}{1\,mol\,CaCl_2} \times \frac{169.9\,g\,AgNO_3}{1\,mol\,AgNO_3}$$

$$= \boxed{30.6\,g}$$

9. $2\,HC_2H_3O_2 + Na_2CO_3 \longrightarrow H_2CO_3 + 2\,NaC_2H_3O_2$

or in aqueous soln: $2\,HC_2H_3O_2 + Na_2CO_3 \rightarrow 2\,NaC_2H_3O_2 + H_2O + CO_2$

$$g\,HC_2H_3O_2 = 3.22\,g\,Na_2CO_3 \times \frac{1\,mol\,Na_2CO_3}{105.99\,g\,Na_2CO_3} \times \frac{2\,mol\,HC_2H_3O_2}{1\,mol\,Na_2CO_3} \times \frac{60.06\,g\,HC_2H_3O_2}{1\,mol\,HC_2H_3O_2}$$

$$= \boxed{3.65\,g}$$

10. $$M = \frac{1.25\,g\,NaCl}{250.0\,mL} \times \frac{1\,mol\,NaCl}{58.44\,g\,NaCl} \times \frac{1000\,mL}{1\,L} = \boxed{0.0856\,M}$$

11. $2\,NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2\,H_2O$

$$mL\,NaOH = 10.0\,mL \times \frac{L}{10^3\,mL} \times \frac{1.3\,mol\,H_2SO_4}{L} \times \frac{2\,mol\,NaOH}{1\,mol\,H_2SO_4} \times \frac{1\,L}{0.252\,mol\,NaOH} \times \frac{10^3\,mL}{1\,L}$$

$$= 103.17\,mL \Rightarrow \boxed{1.0 \times 10^2\,mL}$$

12. $3\,NaHCO_3(s) + H_3PO_4(aq) \rightarrow Na_3PO_4(aq) + 3\,CO_2(g) + 3\,H_2O(l)$

$$g\,NaHCO_3 = 2.33\,mL \times \frac{L}{10^3\,mL} \times \frac{0.85\,mol\,H_3PO_4}{L} \times \frac{3\,mol\,NaHCO_3}{1\,mol\,H_3PO_4} \times \frac{84.01\,g\,NaHCO_3}{1\,mol\,NaHCO_3}$$

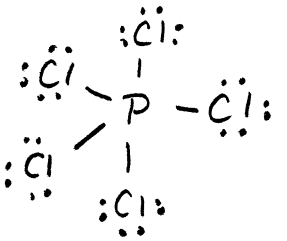
$$= 0.4991\,g \Rightarrow \boxed{0.50\,g}$$

13. $M_2 = \frac{(25\,mL)(0.159\,M)}{120.0\,mL} = \boxed{0.033\,M}$

14. $V_2 = \frac{(125\,mL)(0.100\,M)}{0.222\,M} = \boxed{56.3\,mL}$

15. $[HOAc] = \frac{(10.0\,mL)(0.360\,M)}{10.0\,mL + 15.0\,mL} = \boxed{0.144\,M}$

16. (a) PCl_5 val $e^- = 5 + 5(7) = 40e^-$

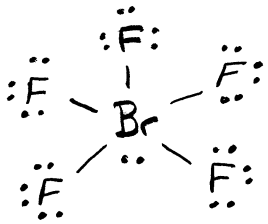


ed geo = trigonal bipyramidal

mol geo = trigonal bipyramidal

hybrid orbitals = sp^3d

(b) BrF_5 val $e^- = 7 + 5(7) = 42e^-$

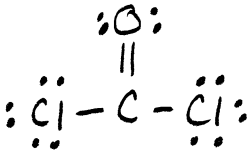


ed geo = octahedral

mol geo = square pyramidal

hybrid orbitals = sp^3d^2

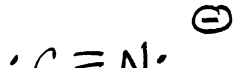
(c) $COCl_2$ val $e^- = 4 + 6 + 2(7) = 24e^-$



ed & mol geo = trigonal planar

hybrid orbitals = sp^2

(d) CN^- val $e^- = 4 + 5 + 1 = 10e^-$



ed & mol geo = linear

hybrid orbitals = sp

17. $kJ = 2.5\,g\ KClO_3 \times \frac{1\,mol\ KClO_3}{122.55\,g\ KClO_3} \times \frac{-89.4\,kJ}{2\,mol\ KClO_3} = \boxed{-0.91\,kJ}$

18. $q = +125\,J$

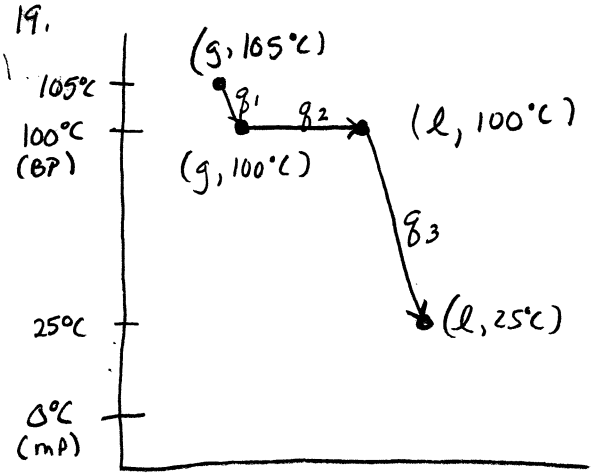
$w = -0.110\,kJ = -110.\,J$

$\Delta E = q + w$

$= 125\,J + -110.\,J$

$= \boxed{15\,J}$

19.



$q_1 = \frac{2.080\,J}{g \cdot K} \times 125\,g \times (100.°C - 105°C)$

$q_1 = -1300\,J \Rightarrow -1.3\,kJ$

$q_2 = \frac{-40.79\,kJ}{mol} \times 125\,g \times \frac{1\,mol}{18.02\,g}$

$q_2 = -282.9\,kJ$

$q_3 = \frac{4.18\,J}{g \cdot K} \times 125\,g \times (25°C - 100.°C) = -39.2\,kJ$

$q_{total} = -1.3\,kJ + -282.9\,kJ + -39.2\,kJ = -323.4\,kJ$

$= \boxed{-323\,kJ}$

20. $q_{H_2O} = \frac{4.18\,J}{g \cdot K} \times 25.0\,g \times 7.0°C = 731.5\,J$

$q_{metal} = -q_{H_2O} = -731.5\,J$

$C_{metal} = \frac{-731.5\,J}{(26.4\,g)(-72.0°C)} = \boxed{0.38\,J/g \cdot K}$

21. $q_{soln} = \frac{4.18\ J}{g \cdot K} \times 35.0\ g \times -5.7\ K = -833.91\ J$

$q_{KBr} = -q_{soln} = +833.91\ J$

$\Delta H_{soln} = \frac{+833.91\ J}{5.0\ g\ KBr} \times \frac{119.0\ g\ KBr}{1\ mol\ KBr} \times \frac{1\ kJ}{1000\ J} = 19.847$

$= \boxed{20.\ \frac{kJ}{mol}}$

22. (a) LDF

(b) LDF, dipole-dipole, hydrogen bonding

(c) LDF, dipole-dipole, hydrogen bonding

(d) LDF, dipole-dipole

(e) LDF

(f) LDF, dipole-dipole

23. $CH_3CH(CH_3)CH_3 < CH_3CH_2CH_2CH_3 < CH_3C(=O)CH_3 < CH_3CH_2CH_2OH$ (highest BP)

24. $CH_3CH_2CH_2OH < CH_3C(=O)CH_3 < CH_3CH_2CH_2CH_3 < CH_3CH(CH_3)CH_3$ (highest VP)

25. (a) freezing
(b) sublimation
(c) solid, liquid, gas
(d) solid & liquid
(e) liquid & gas
(f) point C
(g) point F

26(a) mass % HCl = $\frac{10.2\,g}{10.2\,g + 100.0\,g} \times 100\% = \boxed{9.26\%}$

(b) mol HCl = $10.2\,g \times \frac{1\,mol}{36.46\,g} = 0.2798\,mol$

mol H_2O = $100.0\,g \times \frac{1\,mol}{18.02\,g} = 5.5494\,mol$

mol % HCl = $\frac{0.2798\,mol}{0.2798\,mol + 5.5494\,mol} \times 100 = \boxed{4.80\ mol\%}$

(c) molality = $\frac{0.2798\,mol}{100.0\,g} \times \frac{10^3\,g}{1\,kg} = \boxed{2.80\ m}$

27. Rate = $k[NO]^m[O_2]^n$

To find m, use expts 1 & 2

$\left(\frac{0.018\,M}{0.012\,M}\right)^m = \frac{0.2295}{0.102} = 2.25$

$1.5^m = 2.25$

$m = 2$

To find n, use expts 2 & 3

$\left(\frac{0.040\,M}{0.020\,M}\right)^n = \frac{0.459}{0.2295} = 2.00$

$2.0^n = 2.00$

$n = 1$

Rate = $k[NO]^2[O_2]$

Find k using data from expt 1:

$k = \frac{0.102\,M/s}{(0.012\,M)^2(0.020\,M)} = 35{,}417 \Rightarrow 35{,}000\ M^{-2}s^{-1}$

$\boxed{\text{Rate} = 35{,}000\ M^{-2}s^{-1}[NO]^2[O_2]}$

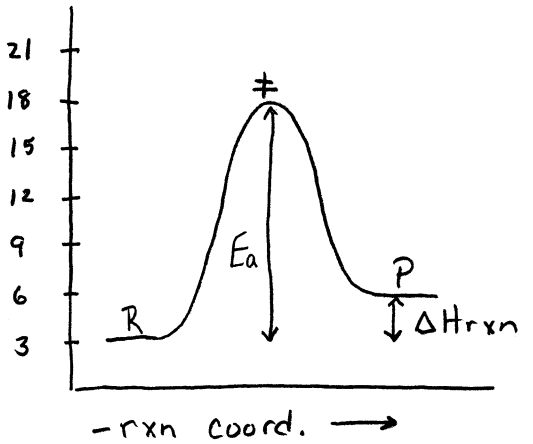
$\boxed{\text{overall order} = 2 + 1 = 3}$

28. $\text{Rate} = -\dfrac{(0.22\,M - 0.54\,M)}{50.0\,\text{min} - 20.0\,\text{min}} = 0.010667 \Rightarrow \boxed{0.011\,M/\text{min}}$

29. $-\dfrac{\Delta[Br_2]}{\Delta t} = \dfrac{1}{2}\dfrac{\Delta[NOBr]}{\Delta t}$

30. $\dfrac{1.6 \times 10^{-3}\,\text{mol NOBr}}{L \cdot s} \times \dfrac{1\,\text{mol } Br_2}{2\,\text{mol NOBr}} = \boxed{8.0 \times 10^{-4}\,M/s}$

31.



32. (a) $K_c = \dfrac{[SO_3]^2}{[SO_2]^2[O_2]}$ (b) $K_c = \dfrac{[H_2O]}{[H_2]}$

33. $K_P = \dfrac{P_{SO_3}^2}{P_{SO_2}^2 \cdot P_{O_2}}$

34. $K_c = \dfrac{[NH_3]^2}{[N_2][H_2]^3} = \dfrac{(0.0310)^2}{(0.0850)(3.10 \times 10^{-3})^3} = \boxed{3.80 \times 10^5}$

35. $Ag_2SO_4(s) \rightleftharpoons 2\,Ag^+(aq) + SO_4^{2-}(aq)$ $K_{sp} = 1.5 \times 10^{-5}$

I	0	0
Δ	+2x	x
E	2x	x

$K_{sp} = [Ag^+]^2[SO_4^{2-}] = 1.5 \times 10^{-5}$

$(2x)^2(x) = 1.5 \times 10^{-5}$

$4x^3 = 1.5 \times 10^{-5}$

$x^3 = 3.75 \times 10^{-6}$

$x = 1.554 \times 10^{-2}$

$[Ag^+] = 2x = 3.1 \times 10^{-2}\ M$

$[SO_4^{2-}] = x = 1.6 \times 10^{-2}\ M$

36. $H_2(g) + I_2(g) \rightleftharpoons 2\,HI$ $K_c = 50.5$

I	0.5000 M	0.5000 M	0
Δ	−x	−x	+2x
E	0.5000 − x	0.5000 − x	2x

$K_c = \dfrac{[HI]^2}{[H_2][I_2]} = 50.5$

$\dfrac{(2x)^2}{(0.5-x)(0.5-x)} = 50.5$

$\dfrac{2x}{0.5000-x} = \sqrt{50.5} = 7.1063$

$2x = 3.553 - 7.1063x$

$9.1063x = 3.553$

$x = 0.390$

$[H_2] = [I_2] = 0.5000 - 0.390$

$[H_2] = [I_2] = 0.110\ M$

$[HI] = 2(0.390) = 0.780\ M$

37. (a) shifts towards products
(b) shifts towards reactants
(c) no change b/c $\Delta n = 0$
(d) shifts towards reactants
(e) shifts towards reactants
(f) shifts towards products

38. $[H^+] = \boxed{1.65 \times 10^{-4}\ M}$

$[OH^-] = \dfrac{1.00 \times 10^{-14}}{1.65 \times 10^{-4}} = \boxed{6.06 \times 10^{-11}\ M}$

$pH = -\log(1.65 \times 10^{-4}) = \boxed{3.783}$

$pOH = -\log(6.06 \times 10^{-11}) = \boxed{10.218}$

39. $[OH^-] = 2.40 \times 10^{-5} \dfrac{mol\ Ca(OH)_2}{L} \times \dfrac{2\ mol\ OH^-}{1\ mol\ Ca(OH)_2} = \boxed{4.80 \times 10^{-5}\ M}$

$pOH = -\log(4.80 \times 10^{-5}) = 4.319$

$pH = 14.000 - 4.319 = \boxed{9.681}$

40. $HC_7H_5O_2(aq) \rightleftharpoons H^+(aq) + C_7H_5O_2^-(aq) \quad K_a = 6.3 \times 10^{-5}$

I	0.200 M	0	0
Δ	$-x$	$+x$	$+x$
E	$0.200 - x$	x	x

$K_a = \dfrac{[H^+][C_7H_5O_2^-]}{[HC_7H_5O_2]} = 6.3 \times 10^{-5}$

$\dfrac{(x)(x)}{0.200 - x} = 6.3 \times 10^{-5}$

Assume $x << 0.200$, then $0.200 - x \approx 0.200$

$\dfrac{x^2}{0.200} = 6.3 \times 10^{-5}$

$x = 3.55 \times 10^{-3}$

✓ Assumption: $\dfrac{3.55 \times 10^{-3}}{0.200} \times 100 = 1.78\% < 5\%$ so valid

$[H^+] = 3.55 \times 10^{-3}$

$pH = 2.4498$

$\boxed{pH = 2.45}$

41. (a) 2 equivalence pts (b) 60.0 mL

(c) $\text{mol acid} = 60.0\text{mL} \times \frac{\text{L}}{10^3\text{mL}} \times \frac{0.125\text{mol KOH}}{\text{L}} \times \frac{1\text{mol } H_2X}{2\text{mol KOH}} = 3.75\times10^{-3}\ \frac{\text{mol}}{H_2X}$

$\text{molar mass} = \frac{0.525\text{g}}{3.75\times10^{-3}\text{mol}} = \boxed{140.\ \text{g/mol}}$

(d) $pKa_1 = \sim 1.5$ $pKa_2 = \sim 4.2$

42. $NH_2OH + C_6H_5NH^+ \rightarrow NH_3OH^+ + C_5H_5N$

BL base BL acid conj. acid conj. base

43. $(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O) \times 2$

$(2Cl^- \rightarrow Cl_2 + 2e^-) \times 5$

$2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{2+} + 8H_2O$

$10Cl^- \rightarrow 5Cl_2 + 10e^-$

$\boxed{2MnO_4^- + 10Cl^- + 16H^+ \rightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O}$

44. $2MnO_4^- + 10Cl^- + 16H^+ \rightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$

+7 -2 -1 +1 +2 0 +1 -2

red

oxid

element reduced = Mn reducing agent = Cl^-

element oxidized = Cl oxidizing agent = MnO_4^-

45. $Al^{3+} + 3e^- \rightarrow Al$ $\quad E^\circ_{red} = -1.66\,V$ (anode)

$Cu^{2+} + 2e^- \rightarrow Cu$ $\quad E^\circ_{red} = +0.337\,V$ (cathode)

$E^\circ_{cell} = E^\circ_{red}\,(cathode) - E^\circ_{red}\,(anode) = 0.337\,V - (-1.66\,V)$

$E^\circ_{cell} = 1.997\,V = \boxed{2.00\,V}$

46. cathode rxn (reduction): $(Cu^{2+} + 2e^- \rightarrow Cu) \times 3$

anode rxn (oxidation): $(Al \rightarrow Al^{3+} + 3e^-) \times 2$

overall rxn: $3\,Cu^{2+} + 2Al \rightarrow 3\,Cu + 2\,Al^{3+}$

47. (a) $\Delta S = \oplus$

(b) $\Delta S = \ominus$

(c) $\Delta S = \oplus$

48. $\Delta G^\circ = \sum n\Delta G_f^\circ\,(prod) - \sum n\Delta G_f^\circ\,(reactants)$

$\Delta G^\circ = [(2\,mol\,NH_3)(-16.66\,\frac{kJ}{mol})] - [(1\,mol\,N_2)(0\,\frac{kJ}{mol}) + (3\,mol\,H_2)(0\,\frac{kJ}{mol})]$

$= \boxed{-33.32\,kJ}$ Notice the units!

49. $Ag_3PO_4(s) \rightleftharpoons 3\,Ag^+(aq) + PO_4^{3-}(aq)$ $\quad \Delta G^\circ = 100.3\,kJ$ (@ 298 K)

$K_{sp} = e^{-\Delta G^\circ/RT} = e^{-100{,}300/[(8.314)(298)]}$

$K_{sp} = e^{-40.48318} = 2.620 \times 10^{-18}$ (cont. next pg)

49. (cont) $Ag_3PO_4(s) \rightleftharpoons 3Ag^+(aq) + PO_4^{3-}(aq)$

I	0	0
Δ	+3x	+x
E	3x	x

$$K_{sp} = [Ag^+]^3[PO_4^{3-}] = 2.620 \times 10^{-18}$$

$$(3x)^3(x) = 2.620 \times 10^{-18}$$

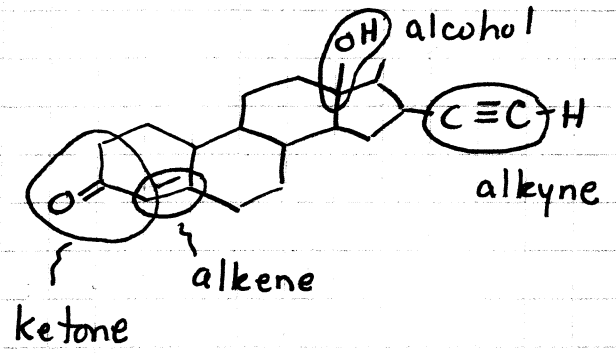
$$27x^4 = 2.620 \times 10^{-18}$$

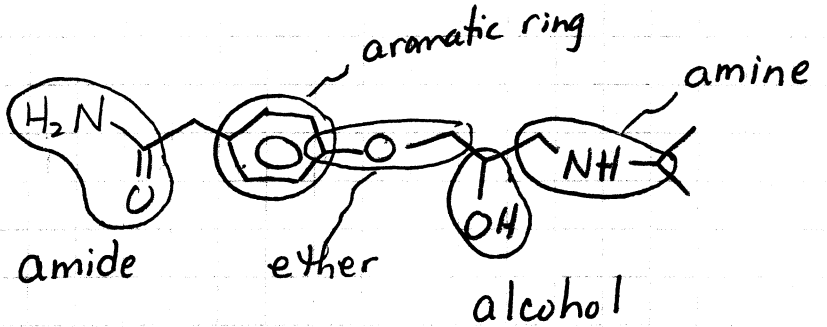
$$x = 1.76496 \times 10^{-5}$$

$$[Ag^+] = 3x = 3(1.76496 \times 10^{-5} M) = \boxed{5.29 \times 10^{-5} M}$$

$$[PO_4^{3-}] = x = \boxed{1.76 \times 10^{-5} M}$$

50.

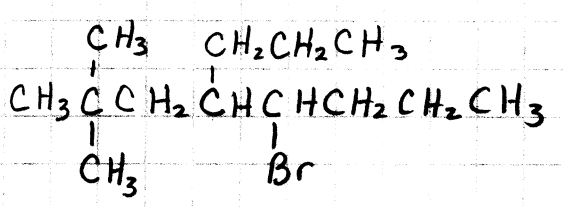
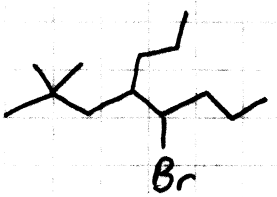


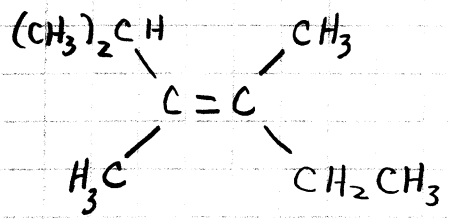
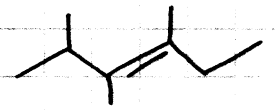


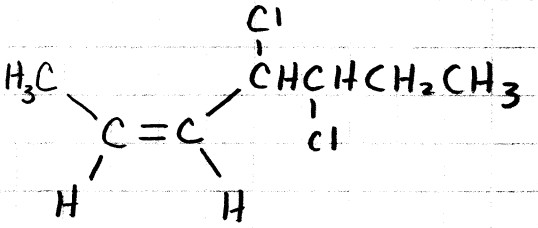
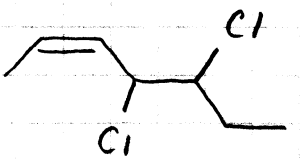
51. 6,8-diethyl-4-decanol

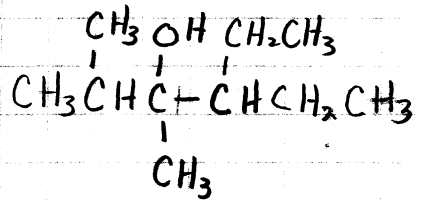
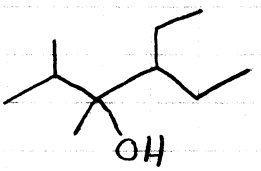
cis-3,4-dimethyl-2-pentene

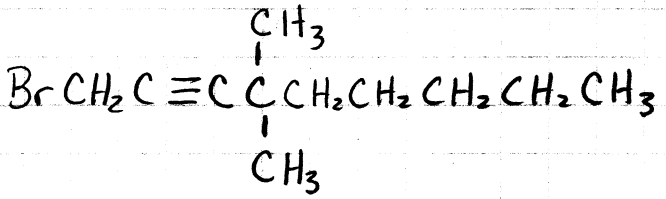
1-bromo-3-ethyl-2,4-dimethylhexane

52. (a)  or 

(b)  or 

(c)  or 

(d)  or 

(e)  or