1. conversion of K_p to K_c

$$2\,Cl_{2(g)} + 2\,H_2O_{(g)} \rightarrow 4\,HCl_{(g)} + O_{2(g)}$$

4 moles gas   5 moles gas

$\Delta n = 5 - 4 = 1$

$$K_c = \frac{K_p}{(RT)^{\Delta n}} = \frac{4.6 \times 10^{-14}}{(.0821)(298)} = 1.88 \times 10^{-15}$$

ANSWER: A) $K_c = 1.9 \times 10^{-15}$

2. $$Q = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{(0.2)(2.25)}{(0.20)} = 2.25 = 2 \text{ (1 sig fig)}$$

$Q > K_c$ ∴ rxn proceeds towards reactants (to the left)

ANSWER: E) NONE OF THESE

3. ANSWER: E - best answer

comments: D is a true statement but is not Le Chatelier's Principle

"stressed" is vague, I agree. Other writers use the phrase "disturbed" or talk about a "perturbation"

4. van't Hoff equation shows that K depends on T

ANSWER: B

5. $$K_c = \frac{[SO_2]^2[O_2]}{[SO_3]^2}$$

	$2SO_3$ →	$2SO_2$	+ O_2
I	0.128		
C	$-2x$	$+2x$	$+x$
E	$0.128 - 2x$	$2x$	x

$x = 0.0130$

$$K_c = \frac{[(2)(0.0130)]^2(0.0130)}{[0.128 - (2)(0.0130)]^2}$$

$K_c = 8.4 \times 10^{-4}$

ANSWER: A

6. $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$

solids do not appear in K_p or K_c expressions

$$K_p = \frac{(pH_2)^4}{(pH_2O)^4}$$ ← from coefficients of balanced reaction.

ANSWER: E

7. pOH = - 0.47

ALERT! outside normal range

$[OH^-] = \text{anti log}\{-(pOH)\}$ $10^{+0.47} = 2.95$

8. $0.272g\ HA \times \frac{1\ mol}{189g} \times \frac{1}{0.025L} = 5.76 \times 10^{-2} = [HA]$

ionization constant means K_a

$$K_a = \frac{X^2}{HA - X} = \frac{X^2}{5.76 \times 10^{-2} - X}$$

pH = 4.93 $[H^+] = 10^{-4.93} = 1.1748 \times 10^{-5} = X$

$$K_a = \frac{(1.1748 \times 10^{-5})^2}{5.76 \times 10^{-2} - 1.1748 \times 10^{-5}} = \frac{1.380 \times 10^{-10}}{5.7588 \times 10^{-2}}$$

$X = 2.4 \times 10^{-9}$

ANSWER: E

9. $NH_4I \rightarrow NH_4^+ + I^-$

NH_4^+ ↑ weak acid

I^- ↑ Spectator ion

$K_{b\,NH_3} = 1.74 \times 10^{-5}$

$\therefore K_{a\,NH_4^+} = \frac{K_w}{K_b} = \frac{1 \times 10^{-14}}{1.74 \times 10^{-5}} = 5.75 \times 10^{-10}$

$[NH_4^+] = 0.300\ M$

$$5.75 \times 10^{-10} = \frac{x^2}{0.300 - x} \cong \frac{x^2}{0.300}$$

$x = 1.31 \times 10^{-5}$

pH = 4.88

Note: The 263 mL does not enter into the problem.

ANSWER: C

10. pH = ?

0.250 M formic acid $K_a = 1.8 \times 10^{-4}$

$$1.8 \times 10^{-4} = \frac{x^2}{0.250 - x} \cong \frac{x^2}{0.250}$$

$x = 6.7 \times 10^{-3}$

pH = 2.17

ANSWER: B

11. The answer is B because sodium chloride is not an acid or a base but I agree that the question is poorly worded.

12. $Ka = 6.3 \times 10^{-5}$ $pKa = 4.20$

$4.20 - 1 = 3.20$
$4.20 + 1 = 5.20$

Range = 3.20 to 5.20

ANSWER: E

13. 0.30m acetic acid (weak acid)

$HA + OH^- \rightarrow A^- + H_2O$
0.30M 0.15M

☑ At the equivalence point essentially ALL of HA has been converted to A^-

☑ It takes twice the volume of OH^- as HA to reach the equivalence point.

$[A^-] = \frac{0.3}{3}$ - trace that is left as HA

$Ka = 1.8 \times 10^{-5}$

$Kb = 5.5 \times 10^{-10} = \frac{x^2}{\frac{0.3}{3}}$

$x = 7.4 \times 10^{-6}$
$pOH = 5.13$
$pH = 8.87$ ← {thymol blue}

14. This is a buffer. The initial concentrations will not change very much. Since the concentration of HF > F^- it is reasonable to expect a slight shift towards more F^-. Answer A is very close to 1.045 and therefore the best answer.

15. NH_4Cl is a weak acid.
The pH will decrease.

ANSWER: B

16. $K_{sp} = 7.6 \times 10^{-7} = s^2$

$s = 8.7 \times 10^{-4}$

ANSWER: D

17. MX_2 114 g/mol

$$\frac{3.42\,g}{L} \times \frac{1\,mol}{114\,g} = 3 \times 10^{-2} = s \text{ (molar solubility)}$$

$$K_{sp} = 4s^3 = 1.08 \times 10^{-4}$$

ANSWER: B

18. $1.5\times10^{-8} = [Ba^{2+}][C_2O_4^{2-}]$

$1.5\times10^{-8} = (5.0\times10^{-5})[C_2O_4^{2-}]$

FIRST $[C_2O_4^{2-}] = 3.0\times10^{-4}$ when Barium ion precipitates

$1.35\times10^{-9} = [Zn^{2+}][C_2O_4^{2-}]$

$1.35\times10^{-9} = (2.0\times10^{-7})[C_2O_4^{2-}]$

SECOND $[C_2O_4^{2-}] = 6.75\times10^{-3}$ when Zinc ion precipitates

$1.1\times10^{-11} = [Ag^{+}]^2[C_2O_4^{2-}]$

$1.1\times10^{-11} = (3.0\times10^{-5})^2[C_2O_4^{2-}]$

THIRD $[C_2O_4^{2-}] = 1.22\times10^{-2}$ when silver ion ppt.

when the second ion, zinc, begins to precipitate the $[C_2O_4^{2-}] = 6.75\times10^{-3}$

FOR Ba^{2+}

$1.5\times10^{-8} = [Ba^{2+}]6.75\times10^{-3}$

$[Ba^{2+}] = 2.22\times10^{-6}$

ANSWER: B

19. $1.0 \times 10^{-6} = s^2$ for MX $s = 1.0 \times 10^{-3}$

$1.0 \times 10^{-6} = 4s^3$ for M_2X and MX_2

$s = 6.3 \times 10^{-3}$

$1.0 \times 10^{-6} = 27s^4$ for MX_3 $s = 1.39 \times 10^{-2}$

largest s

ANSWER: C

20. $[Pb^{2+}] = 4.8 \times 10^{-6}$

$4.8 \times 10^{-6} \frac{\text{moles}}{L} \times 0.1\,L = 4.8 \times 10^{-7}$ moles

$1.00\,M$ NaI $\times$ 10mL = 10 mmoles = 0.01 mol

$$Q = \left(\frac{0.01}{0.11}\right)^2 \left(\frac{4.8 \times 10^{-7}}{0.11}\right) = 3.6 \times 10^{-8}$$

total volume 100mL + 10mL → 0.11

$Q > K_{sp}$ so precipitation will occur.

ANSWER: B

21. $5.9 \times 10^{-3} = (s)(0.10)$

$s = 5.9 \times 10^{-2}$

ANSWER: B

22. $2 NO(g) \rightarrow N_2O_4(g)$

$\Delta n = 1 - 2 = -1$

$K_p = K_c (RT)^{\Delta n}$ $K_p = K_c (RT)^{-1}$ $K_p = \frac{K_c}{RT}$

ANSWER: D

23. weak acids

phenol pKa = 7.54

weak bases

pyridine pKb = 8.82

triethylamine pKb = 3.25

ammonia pKb = 4.74

strong acids

$HClO_4$

strong bases

NaOH

Possible buffers

phenol + NaOH	pH ~ 7.54
* pyridine + $HClO_4$	pH ~ 14 - 8.82 = 5.18
triethylamine + $HClO_4$	pH ~ 14 - 3.25 = 10.75
ammonia + $HClO_4$	pH ~ 14 - 4.74 = 9.26

answer: A

24. No effect

ANSWER B

25. H_2O is a base in this reaction

$C_2H_3O_2^-$ is a base

acid + base → weaker acid + weaker base

ANSWER: B

26. ~ 7.4 middle of second flat region.