6. C

$$NH_{3(g)} + H_2S_{(g)} \rightleftharpoons NH_4HS_{(s)}$$

$$K = \frac{1}{[NH_3][H_2S]}$$

	NH_3	H_2S	NH_4HS
I	2M	2M	Ø
C	−x	−x	+x
E	2−x	2−x	x

* $NH_4HS_{(s)}$ is not included because it is a solid however we have synthesized it so there is x more $NH_4HS_{(s)}$

$$\sqrt{\frac{1}{(2-x)^2}} = \sqrt{9.7}$$

$$\frac{1}{2-x} = 3.1145, \quad 1 = 6.229 - 3.1145x, \quad 3.1145x = 5.229,$$

$$x = 1.679\,mol/L \times 1L = 1.7\,mol$$

7. D Volume/pressure changes affect only gaseous systems.

High P = Low V → shift to side with less moles of gas

Low P = High V → shift to side w/ more moles of gas

I) Moles gas in reactant = moles gas in product ← unaffected!

III) same!

8. D

$$CH_3COO^-_{(aq)} + \cancel{H^+_{(aq)}} \rightleftharpoons CH_3COOH_{(aq)} \qquad K = \frac{1}{Ka} = \frac{1}{1.8\times10^{-5}}$$

×

$$H_2O_{(l)} \rightleftharpoons \cancel{H^+_{(aq)}} + OH^-_{(aq)} \qquad Kw = 10^{-14}$$

||

$$CH_3COO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + OH^-_{(aq)} \qquad K = \frac{Kw}{Ka} = \frac{10^{-14}}{1.8\times10^{-15}} = 5.56\times10^{-10}$$

9. B

$0.5L \times 0.120M$ KOH $= 0.06\,mol$ KOH

$0.06\,mol\ OH^-$ +

$0.5L \times 0.048M\ Ba(OH)_2$

$0.024\,mol\ Ba(OH)_2$

$0.048\,mol\ OH^-$

$$= \frac{0.108\,mol\ OH^-}{1L}$$

$-\log(0.108M\ OH^-) = pOH = 0.967$

$pH = 13.03$

10. B $0.18M\ NaOCl$, $pH=10.38$, $pOH=3.62$, $[OH^-]=10^{-3.62}$

$$OCl^- + H_2O \rightleftharpoons HOCl + OH^-$$

	OCl^-	H_2O	$HOCl$	OH^-
I	0.18	$\times$	Ø	Ø
C	$-x$		$+x$	$+x$
E	$0.18-10^{-3.62}$		$10^{-3.62}$	$10^{-3.62}$

$$Kb=\frac{(10^{-3.62})^2}{(0.18-10^{-3.62})}=3.2012\times10^{-7},\ \frac{Kw}{Kb}=Ka=3.124\times10^{-8}$$

11. A $H_3O^+_{(aq)} + NO_2^-{}_{(aq)} \longrightarrow HNO_{2(aq)} + H_2O_{(l)}$

12. D The indicator needs to have a pKa as close as possible to the pH at equivalence, at equivalence, 0.1 M lactic acid will become 0.05M conjugate base due to the 1:1 dilution with the KOH. Therefore:

$$A^-_{(aq)} + H_2O_{(l)} \rightleftharpoons HA_{(aq)} + OH^-_{(aq)}$$

	A^-	H_2O	HA	OH^-
I	0.05	$\times$	0	0
C	$-x$		$+x$	$+x$
E	$0.05-x$		x	x

$$\frac{x^2}{0.05-x}=Kb=10^{-10.9},\ x=7.746\times10^{-7}$$

$pKa=3.1$, $pKb=14-pKa=10.9$

$pOH=6.11$, $pH=7.89$

phenol red is closest

13. C $NH_{3(aq)} + HCl_{(aq)} \longrightarrow NH_4Cl_{(aq)}$

NH_3	HCl
1 M	0.5M
0.1L	0.1L
0.1 mol	0.05mol
excess	

* After the reaction has gone to completion (stoich, not equilibrium) there will be 0.05mol of NH_3 and 0.05 mol of NH_4Cl.

14. B $PbBr_{2(s)} \rightarrow Pb^{2+} + 2Br^-$

	$PbBr_2$	Pb^{2+}	Br^-
I	?	Ø	Ø
C	$-x$	$+x$	$+2x$
E	$?-x$	x	$2x$

$Ksp=7.9\times10^{-5}=(2x)^2(x)$,

$4x^3=7.9\times10^{-5}$

$x=2.703\times10^{-2}M$

15. E

$PbF_2 \rightarrow F^-$ base
$Ca(OH)_2 \rightarrow OH^-$ base
$Na_2CO_3 \rightarrow CO_3^{2-}$ base
$SnS \rightarrow S^{2-}$ base
$AgI \rightarrow I^-$ neutral

the base is used up, Le Chatelier's principle forces the system to shift right.

16. C The strongest oxidizing agent has the most positive reduction potential. Fe^{2+}/Fe and $Fe_{(s)}$ is the best reducing agent.

17. A)

Ø gain 1e⁻ to -1 reduction (Cathode)

$$Cl_2 + 2Br^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + Br_{2(l)}$$

-1 to Ø lose 1e⁻ oxidation (Anode)

need a solid electrode; Anode; So; salt bridge; Cathode; phase boundary; need a solid electrode

$$Pt_{(s)} | Br^-_{(aq)}, Br_{2(l)} || Cl_{2(g)} | Cl^-_{(aq)} | Pt_{(s)}$$

* the ideal answer is not present, A) is the closest solution.

18. C

$$Cu_{(s)} | Cu^{2+}(0.1M) || Cu^{2+}(2M) | Cu_{(s)}$$

$Cu \rightarrow Cu^{2+} + 2e^-$ $E = -0.337V$
$2e^- + Cu^{2+} \rightarrow Cu$ $E = 0.337V$
$E° = ØV$

$$E = E° - \frac{0.0592}{n} \log(Q),$$
$$E = Ø - \frac{0.0592}{2} \log\left(\frac{0.1M}{2M}\right)$$
$$E = 0.0385 V$$

19. C

$$Zn_{(s)} + 2H^+ \rightleftharpoons H_2 + Zn^{2+}$$

$$\underset{0.66V}{E} = \underset{0.76V}{E°} - \frac{0.0592}{2} \log\left(\frac{\overset{P_{H_2}}{\cancel{[H_2]}}[Zn^{2+}]}{[H^+]^2}\right)$$

$$0.66 = 0.76 - \frac{0.0592}{2} \log\left(\frac{1 \times 0.2}{(4\times10^{-3})^2}\right)$$

$$0.1 = \frac{0.0592}{2} \log\left(\frac{1\times0.2}{x^2}\right)$$
$$x = 9.15\times10^{-3}$$

20. B $\quad n_{e^-} = \frac{It}{F} \rightarrow \frac{0.6A \times 844s}{9.65\times10^{4}\,C/mole^-} = 5.25\times10^{-3}\,mole^- \times \frac{1\,MnO_4^-}{5e^-} = \frac{1.05\times10^{-3}\,mol\ MnO_4^-}{0.025L}$

$= 4.20\times10^{-2}\,M$

Planck's constant

21. C $\quad 589nm \rightarrow E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34} \times 3\times10^{-8}\,m/s}{589\times10^{-9}\,m} = 3.377\times10^{-19}\,J/photon$

$\frac{3.377\times10^{-19}\,J}{photon} \times \frac{6.022\times10^{23}\,photons}{mole} \times 1.0\times10^{-4}\,mol = 20.34\,J$

$\downarrow$

$2.03\times10^{-2}\,kJ$

22. B $\quad E = \frac{h\nu}{\lambda} = mv^2 \qquad \frac{6.63\times10^{-34}}{205\times10^{-12}\,m \times 1.67\times10^{-27}\,kg} = 1.937\times10^{3}\,m/s$

23. E
a) False - you can have half filled orbitals
b) False - 3
c) False - 2 nodal planes
d) False - they do, the d is just empty
e) Yes, 7 orbitals = $14e^-$

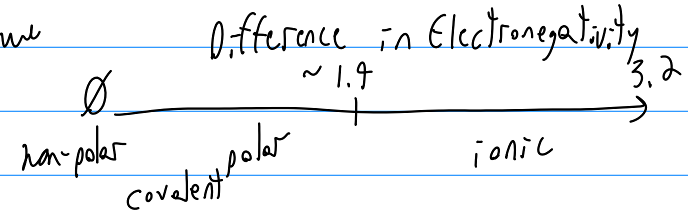
24. E $\quad$ The maximum number of electrons in $2l+2$ and for $n=2$ we have

$$e^- = \sum_{l=\varnothing}^{l=n-1} 2l+2 = 2+6=8 \rightarrow 2n^2$$

if $n=3$ then $2+6+10=18e^- \rightarrow 2n^2$

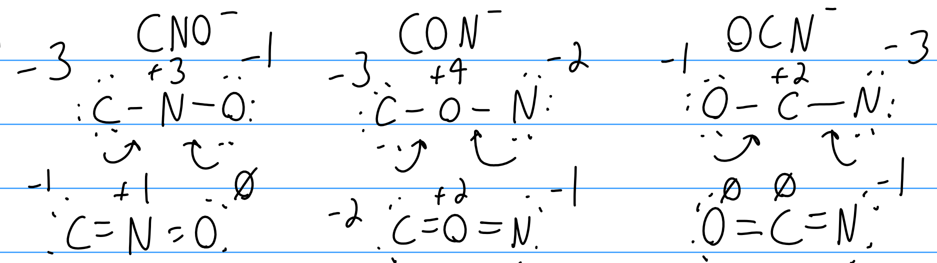
25. A $\quad$ Mo is an exception and would be $[Kr]5s^1 4d^5$

26.
A) → true but depends on who teaches the course
E) true



$4+6+5+1=16e^- = 8$ pairs

27. A



intermediate   least stable   most stable

$CON^- < CNO^- < OCN^-$

28. $rate = K[A]^x[B]^y$ Method of Initial Rates

$$\frac{8.0\times10^{-5}}{3.2\times10^{-4}} = \frac{\cancel{K}[0.15]^x\cancel{(0.25)^y}}{\cancel{K}[0.30]^x\cancel{[0.25]^y}}$$

$$\frac{1}{4} = \left[\frac{1}{2}\right]^x, \quad x=2$$

$$\frac{3.2\times10^{-4}}{5.12\times10^{-3}} = \frac{\cancel{K}[0.3]^2[0.25]^y}{\cancel{K}[0.6]^2[0.5]^y}$$

$$\frac{1}{4} \quad \frac{1}{\cancel{16}} = \cancel{\left(\frac{1}{2}\right)^2}\left(\frac{1}{2}\right)^y \qquad y=2$$

$rate = K[A]^2[B]^2 \rightarrow Ms^{-1} = kM^4$, so units of K are $M^{-3}s^{-1}$

$8\times10^{-5} = k[0.15]^2[0.25]^2$, $k = 5.69\times10^{-2}\ M^{-3}s^{-1}$

29. Galvanic cell (net V = +ve)

$$Ag^+ + e^- \rightleftharpoons Ag(s) \quad E^\circ = 0.80V$$
$$(Fe^{3+} + e^- \rightleftharpoons Fe^{2+} \quad E^\circ = 0.77V) \times -1$$

$$Ag^+ + Fe^{2+} \rightleftharpoons Fe^{3+} + Ag_{(s)} \quad E^\circ = 0.03V$$

a) $E = 0.03V - \frac{0.0592}{1e^-}\log\left(\cancel{\frac{0.001}{0.001\times0.01}}\right)$

but galvanic cell, reaction is reversed, $V = +0.0884$

$= 0.03V - \frac{0.0592\times2}{1} = 0.03V - 0.1184 = -0.0884$

b) Because we need a +ve voltage, the reaction happens opposite of what was predicted:

$$Ag_{(s)} + Fe^{3+}_{(aq)} \rightleftharpoons Fe^{2+}_{(aq)} + Ag^{+}_{(aq)} \qquad E^\circ = -0.03V$$

but $E = +0.0884$ V under these conditions.

c) Change character means from reducing to oxidizing. So when does V go from negative to positive?

$$Ag^{+} + Fe^{2+} \rightleftharpoons Fe^{3+} + Ag_{(s)} \qquad E^\circ = 0.03V$$

$$\cancel{E} = 0.03V - \frac{0.0592}{1e^-} \log\left(\frac{0.001}{[Ag^+]\cdot 0.01}\right)$$

$$0.03 = 0.0592 \log\left(\frac{0.001}{0.01x}\right)$$

$$x = 3.11 \times 10^{-2} \text{ mol/L}$$

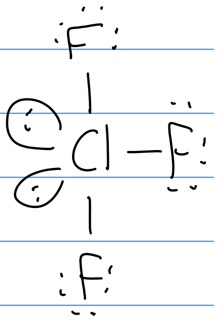
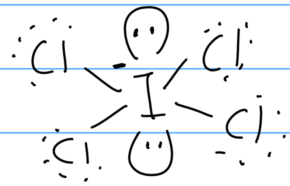
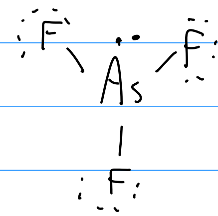
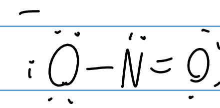
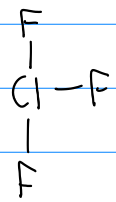
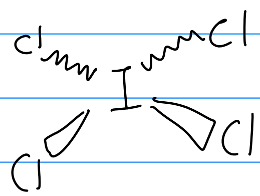
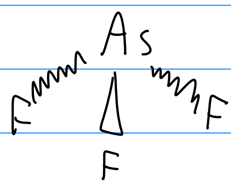
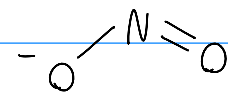
d) When $E = \emptyset$, $Q = K$ so

$$0.03 = \log(K), \quad K = 1.0715 M^{-1}$$ * this is for the reaction

$$Ag^{+} + Fe^{2+} \rightleftharpoons Fe^{3+} + Ag_{(s)} \qquad E^\circ = 0.03V$$

For the opposite reaction which is occurring in the galvanic cell,

$$K = \frac{1}{1.0715} = 0.933 M$$

39.	ClF_3	ICl_4^-	AsF_3	NO_2^-
Lewis Dot				
VSEPR				
Electron pair geometry	trigonal bipyramidal	Octahedral	Tetrahedral	Trigonal Planar
Molecular Geometry	T-shaped	square planar	trigonal pyramidal	bent, $< 120°$
Bond Angles	$< 90°, < 180°$	$\sim 90°$	$< 109.5°$	$< 120°$
Polar or non-polar	Polar	Non-polar	Polar	Polar