

CH301H Fall 2011

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Homework week 9, key

1. a) no:  $4s < 3d < 4p$

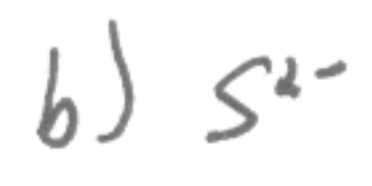
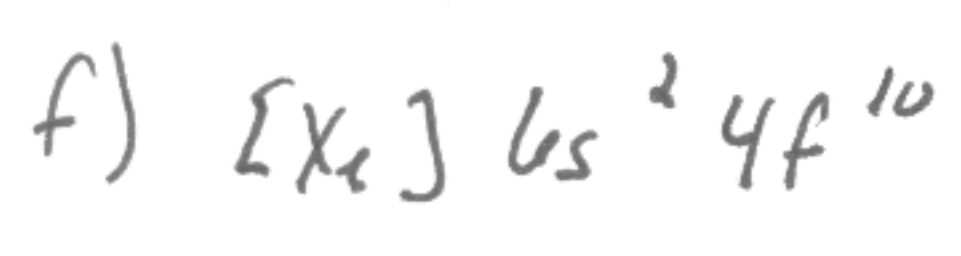
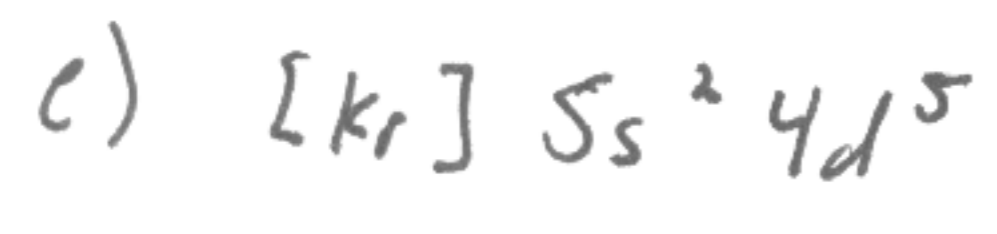
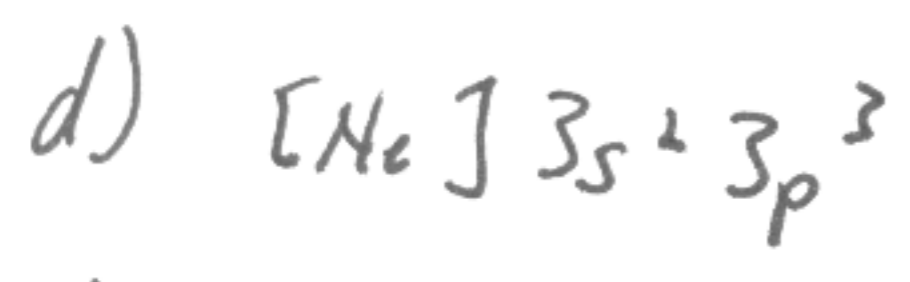
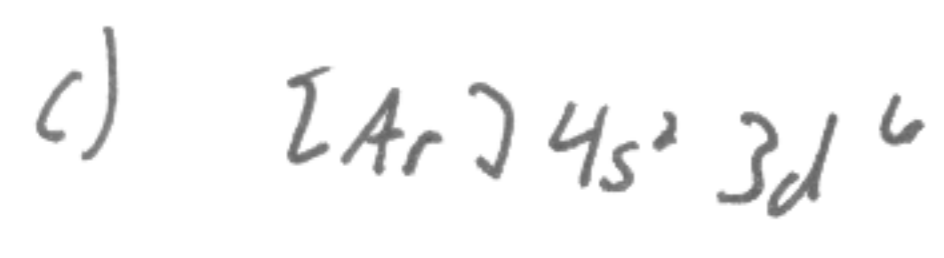
b) yes

c) no:  $3s < 3p < 4s$

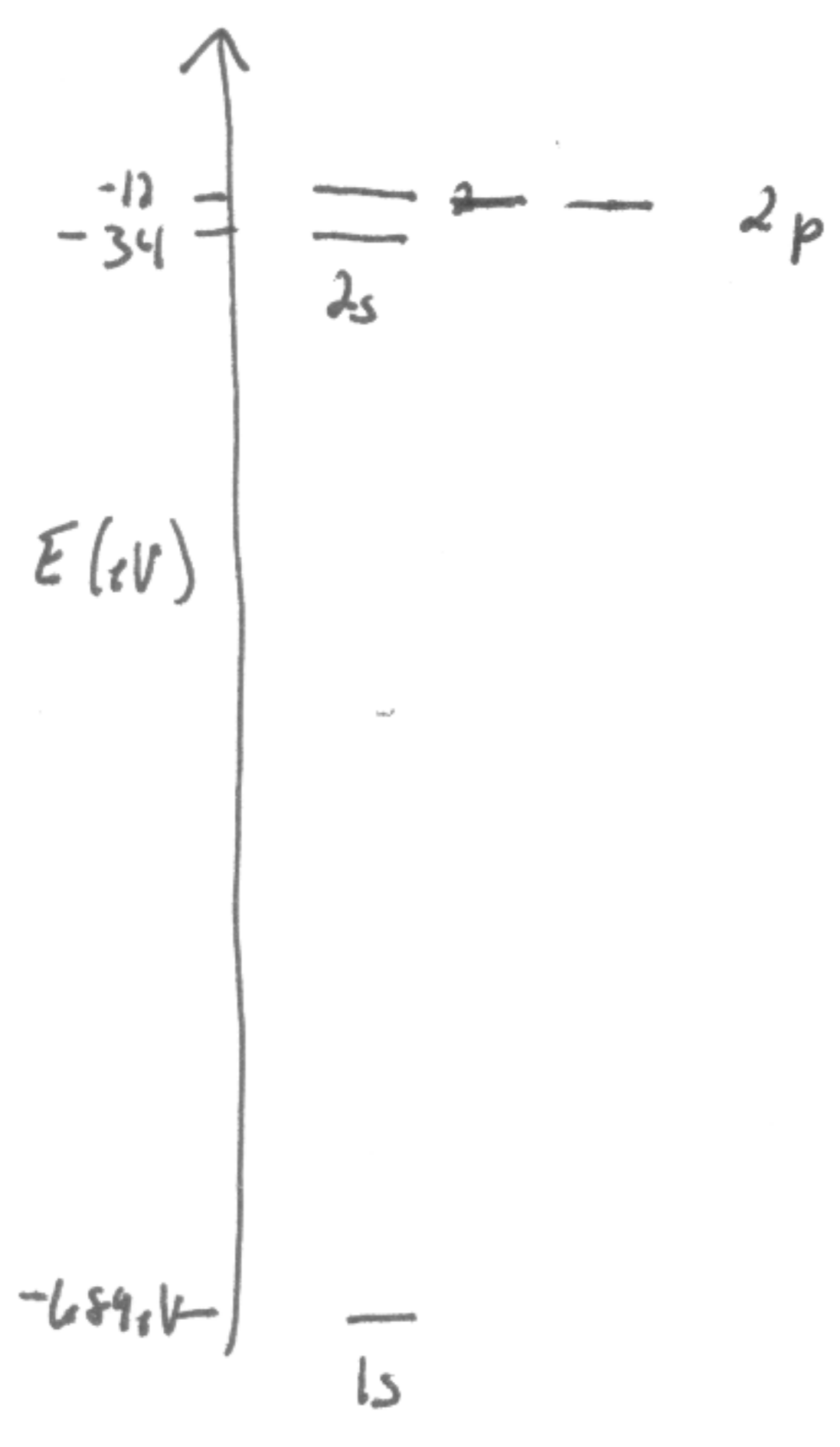
d) no:  $5d < 6p < 7s$

2. We have already seen in Chap. 3 that the trend in EA for the most part makes sense except for the fact that every once in a while, we find an atom for which no stable negative ion exists, and therefore it is very difficult to place an extra electron in that atom.

We now see that this occurs either when we move to an orbital of higher quantum # (i.e. w/ the ideal gases), or when we try to add an electron to a half-filled orbital (like for nitrogen).



5.



The difference in energy between levels of different  $n$  is substantially larger than between orbitals of different  $l$ .

6. a)  $S^{2-}$  is larger - outermost  $e^-$  are in a  $n=3$  orbital not  $n=2$ .

b)  $Ti^{2+}$  is larger - smaller  $Z_{eff}$

c)  $Mn^{2+}$  because of smaller  $Z_{eff}$

d)  $Sr^{2+}$  - larger  $n$ .

7. N:  $1s^2 2s^2 2p^3$

$$\psi^2(r, \theta, \phi) = R^2(r) Y^2(\theta, \phi)$$

From table 5.2, we see that the radial part of the wavefunction does not depend on  $\theta$  or  $\phi$ , so it is already spherically symmetric.

Therefore we only care about the angular part.

$$Y^2(\theta, \phi) = Y^2(p_x) + Y^2(p_y) + Y^2(p_z)$$

$$= C \sin^2 \theta \cos^2 \phi + C \sin^2 \theta \sin^2 \phi + C \cos^2 \theta \quad \text{where } C = \frac{3}{4\pi}$$

$$\sin^2 \phi + \cos^2 \phi = 1; \quad \cos^2 \phi = 1 - \sin^2 \phi$$

$$Y^2(\theta, \phi) = C \sin^2 \theta - C \sin^2 \theta \sin^2 \phi + C \sin^2 \theta \sin^2 \phi + C \cos^2 \theta$$

$$= C \sin^2 \theta + C \cos^2 \theta = C (\sin^2 \theta + \cos^2 \theta) = C = Y^2(\theta, \phi)$$

So the angular part of the wavefunction does not ~~depend~~ depend on angle  
 $\Rightarrow$  spherically symmetric.

8. Fe:  $2p \rightarrow 1s$ ,  $\lambda = 0.193 \text{ nm} = 0.193 \times 10^{-9} \text{ m}$

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$$E = \frac{hc}{\lambda} = 1.03 \times 10^{-15} \text{ J} = \text{energy difference between } 2p \text{ and } 1s \text{ states in Fe.}$$

This is a much bigger energy difference than for H atoms.

This is because of the significantly larger nuclear charge for Fe compared to H. All energy levels will be affected, but those closest to the nucleus will be affected the most.