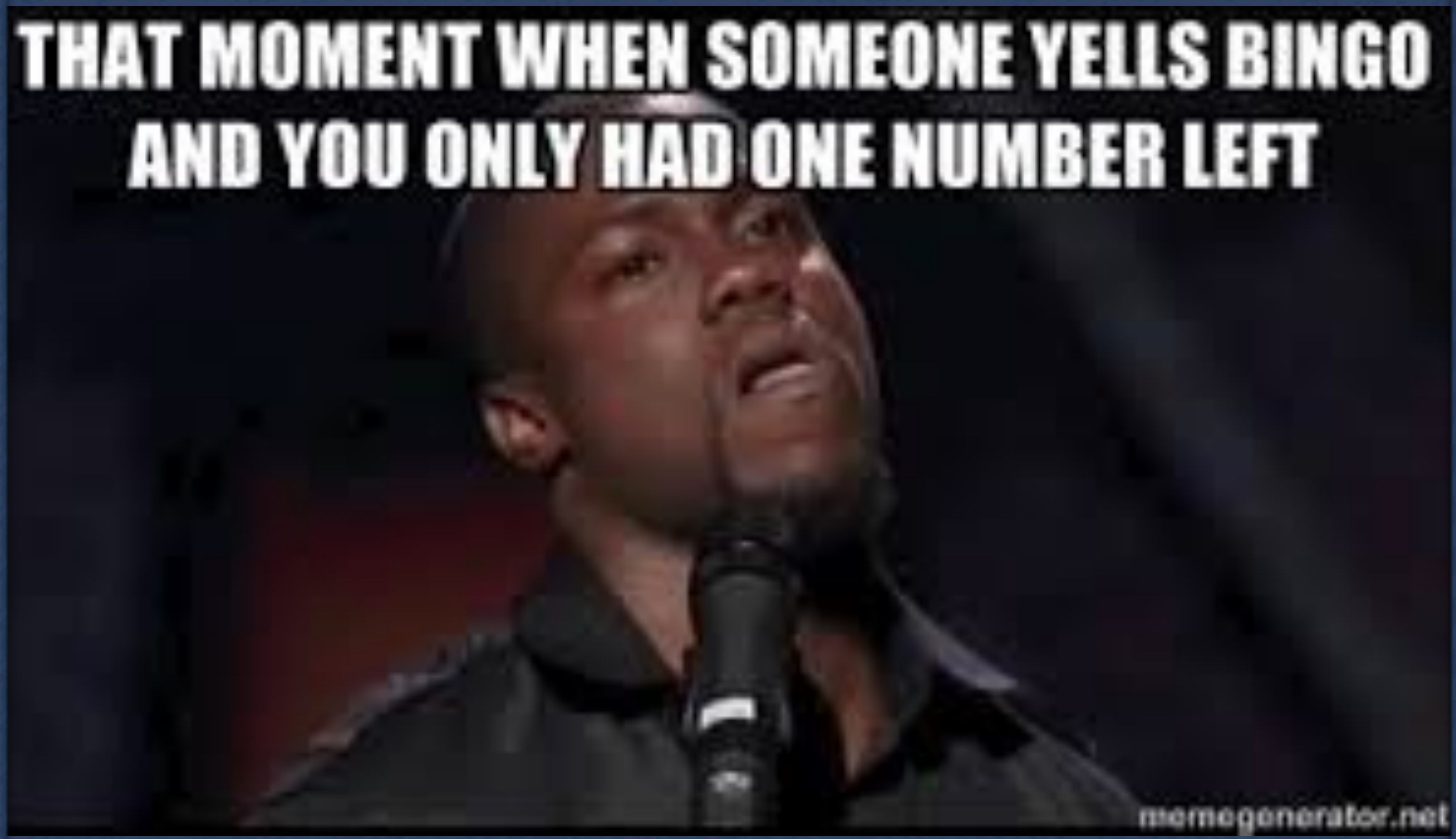


# Electron Configuration

*Friday 11/06/15*

# Agenda

- *Notes Electron Configuration*
- *More practice problems from handout*
- *Electron Configuration Bingo*

# *Topic 2.2*
# *Electron configuration*

- Emission spectra are produced when photons are emitted from atoms as excited electrons return to a lower energy level.
- The line emission spectrum of hydrogen provides evidence for the existence of electrons in discrete energy levels, which converge at higher energies.
- The main energy level or shell is given an integer number, n, and can hold a maximum number of electrons, $2n^2$.
- A more detailed model of the atom describes the division of the main energy level into s, p, d and f sub-levels of successively higher energies.
- Sub-levels contain a fixed number of orbitals, regions of space where there is a high probability of finding an electron.
- Each orbital has a defined energy state for a given electronic configuration and chemical environment and can hold two electrons of opposite spin.

# *Electron Configuration*

## Heisenberg's uncertainty principle questions:

1. The wavelength of a quantum object is determined by its:
   a. Position
   b. Momentum
   c. Composition
   d. Multiple properties
2. For a quantum particle to have a long wavelength, it should have:
   a. Have a large mass and move at high speed
   b. Hard a large mass and move at low speed
   c. Have a small mass and move at high speed
   d. Have a small mass and move at low speed
3. Adding together multiple waves to make a wave packet means that:
   a. There are multiple particles in the packet, each with a different wavelength
   b. There are multiple particles in the packet, each with a different position
   c. The object has a single momentum but can be found in one of many positions
   d. The object has a single position but can be found in one of many momenta

# *Electron Configuration*

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# *Electron Configuration*

## Schrodinger's equation questions:

1. We know quantum particles can occupy more than one state at the same time because:
   a. We find particles confined to a small region of space
   b. We see particles with well-defined momentum
   c. We see electrons interfering after passing through a double slit
   d. We see cats that are both alive and dead

2. We see wave behavior in electrons but not in cats because:
   a. Electrons move much faster than cats
   b. Electrons move much slower than cats
   c. Electrons are easier to control than cats
   d. Electrons have much lower mass than cats

3. An electron in the vicinity of two nearby atoms will be orbiting:
   a. The heavier of the two atoms only
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# ***Electron Configuration***

## **Schrodinger's equation questions:**

4. The behavior of electrons moving through solid objects is determined by:
   a. Electrons bouncing off atoms in the solid like billiard balls
   b. Electrons going around the outside of the solid like waves
   c. Electrons being shared between all of the atoms in the solid
   d. Electrons being pushed through the solid by other electrons

5. Quantum physics is important for computer technology because:
   a. The sharing of electrons between atoms determines the properties of semiconductors
   b. Internet messages are sent using the wave properties of electrons
   c. The flow of electrical current can only be understood in terms of waves
   d. The bits in a modern computer use single electrons

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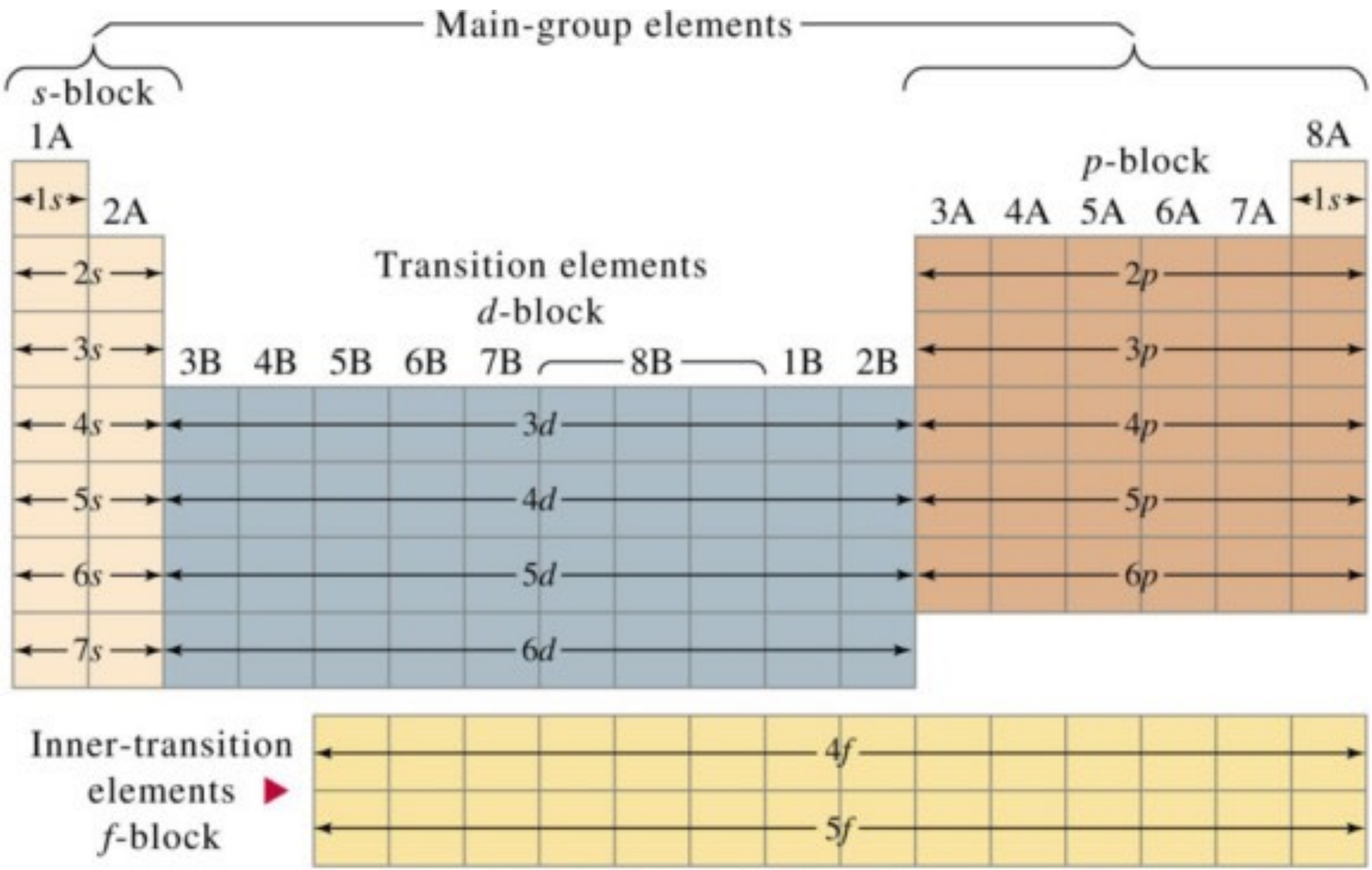
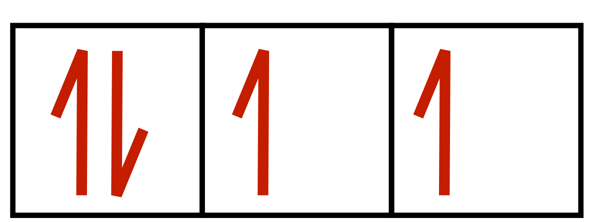


Main-group elements
s-block
1A
2A
1s
2s
3s
4s
5s
6s
7s
Transition elements
d-block
3B 4B 5B 6B 7B 8B 1B 2B
3d
4d
5d
6d
p-block
3A 4A 5A 6A 7A
8A
1s
2p
3p
4p
5p
6p
Inner-transition
elements
f-block
4f
5f

# *Electron Configuration*

## Aufbau principle

- Electrons will fill from the *lowest-energy orbital* that is available <u>first</u>.
- Works up to Ca (Z=20) after that Sc (Z=21), the d orbital fills before the s and p orbitals since it is lower in energy.
- **Electron configuration for Ca (Z=20)**
  - $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$
- **Electron configuration for Sc (Z=21)**
  - $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, **$3d^1$**, $4s^2$ ⟵ *notice the d orbital is filled before the s orbital*
- The **Pauli Exclusion Principle** states that any orbital can hold a maximum of two electrons, and these electrons have opposite spin.
- **Hund's rule of maximum multiplicity** states that when filling **degenerate** orbitals (orbitals of equal energy) electrons fill all the orbitals singly before occupying them in pairs.



2p

# Electron Configuration

**Full electron configuration for first 36 elements**

- Three ways to illustrate electron configuration:
  - *full electron configuration*
  - *condensed electron configuration*
  - *orbital diagram representation*
- Use "build up" method

| Element | Z | Electron configuration |
|---|---|---|
| *Period 1 elements:* | | |
| H | 1 | $1s^1$ |
| He | 2 | $1s^2$ |
| *Period 2 elements:* | | |
| Li | 3 | $1s^22s^1$ |
| Be | 4 | $1s^22s^2$ |
| B | 5 | $1s^22s^22p^1$ |
| C | 6 | $1s^22s^22p^2$ |
| N | 7 | $1s^22s^22p^3$ |
| O | 8 | $1s^22s^22p^4$ |
| F | 9 | $1s^22s^22p^5$ |
| Ne | 10 | $1s^22s^22p^6$ |
| *Period 3 elements:* continue with the same filling pattern, for example: | | |
| Na | 11 | $1s^22s^22p^63s^1$ |
| Mg | 12 | $1s^22s^22p^63s^2$ |
| Al | 13 | $1s^22s^22p^63s^23p^1$ |
| Ar | 18 | $1s^22s^22p^63s^23p^6$ |
| *Period 4 elements:* After $Z = 30$ the 4p sublevel is filled: | | |
| K | 19 | $1s^22s^22p^63s^23p^64s^1$ |
| Ca | 20 | $1s^22s^22p^63s^23p^64s^2$ |
| Sc | 21 | $1s^22s^22p^63s^23p^63d^14s^2$ |
| Ni | 28 | $1s^22s^22p^63s^23p^63d^84s^2$ |
| Zn | 30 | $1s^22s^22p^63s^23p^63d^{10}4s^2$ |
| Ga | 31 | $1s^22s^22p^63s^23p^63d^{10}4s^24p^1$ |
| Br | 35 | $1s^22s^22p^63s^23p^63d^{10}4s^24p^5$ |
| Kr | 36 | $1s^22s^22p^63s^23p^63d^{10}4s^24p^6$ |

# *Electron Configuration*

## Condensed electron configuration

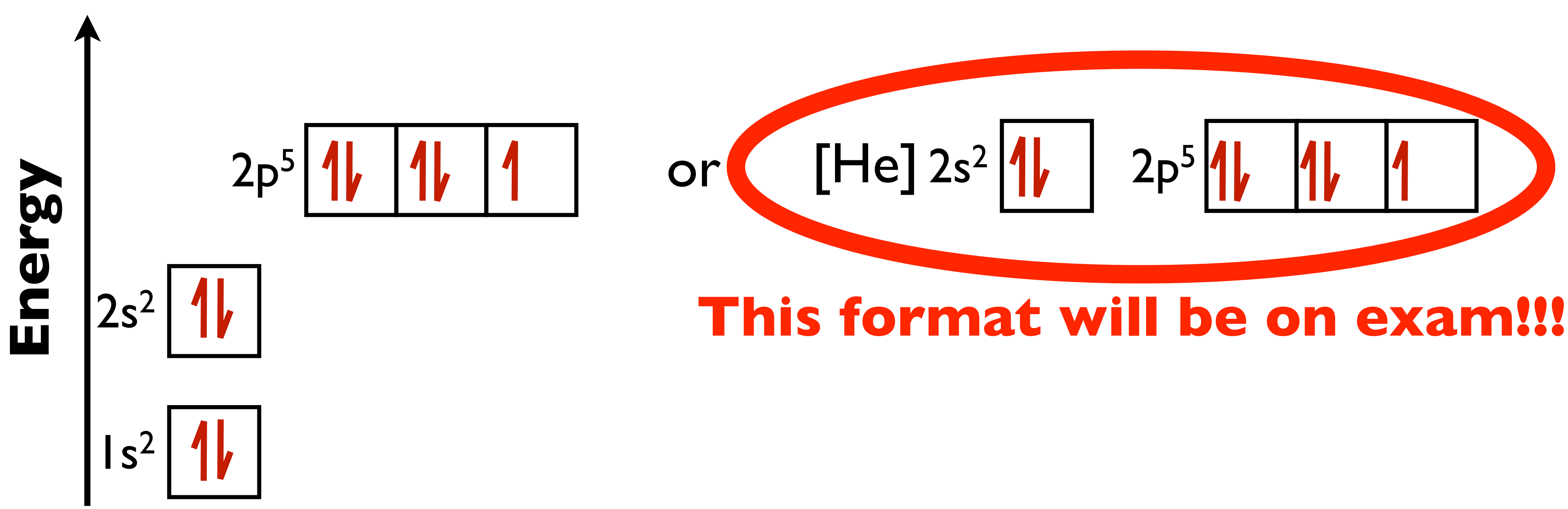
- Full electron configuration can get lengthy so scientists often write in condensed form:
  - [nearest noble gas] + valence electrons
  - Valence electrons are responsible for chemical reactions
- For example:

| | |
|---|---|
| He | [He] |
| O | [He] $2s^2$ , $2p^4$ |
| Ne | [He] $2s^2$ , $2p^6$ or simply [Ne] |
| P | [Ne] $3s^2$ , $3p^3$ |

# *Electron Configuration*

## Orbital diagrams

- **Orbital diagrams** uses the arrows in boxes notation
  - Electrons are represented by arrows ⥮
  - Boxes represent orbitals
  - Degenerate orbitals are joined together to show their energy equivalence
  - Can show full configuration or just from nearest noble gas
  - Fluorine $1s^2, 2s^2, 2p^5$




**This format will be on exam!!!!**

# Practice Problem

## ... I Do ...

What is the order of increasing energy of the orbitals within a single energy level?

A) d < s < f < p

B) s < p < d < f

C) p < s < f < d

D) f < d < p < s

# Practice Problem

## ... We Do ...

List the following types of electromagnetic radiation in order of **increasing** wavelength (shortest first).

I. Yellow light
II. Red light
III. Infrared radiation
IV. Ultraviolet radiation

b) Distinguish between a continuous spectrum and a line spectrum.

# Practice Problem

10 mins

## ... We Do ...

**Work with a partner or alone and answer the following questions:**

*a) Deduce the full electron configuration for Mn and $Mn^{2+}$.*

*b) Deduce the condensed electron configuration for $Cu^{2+}$.*

*c) Draw orbital diagrams for $Co^{2+}$ and As.*

**Go fast! We still have to play bingo!**

# Topic 2.2
# Electron configuration

- ➡ Emission spectra are produced when photons are emitted from atoms as excited electrons return to a lower energy level.
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