Researcher Qualifications Answer Key

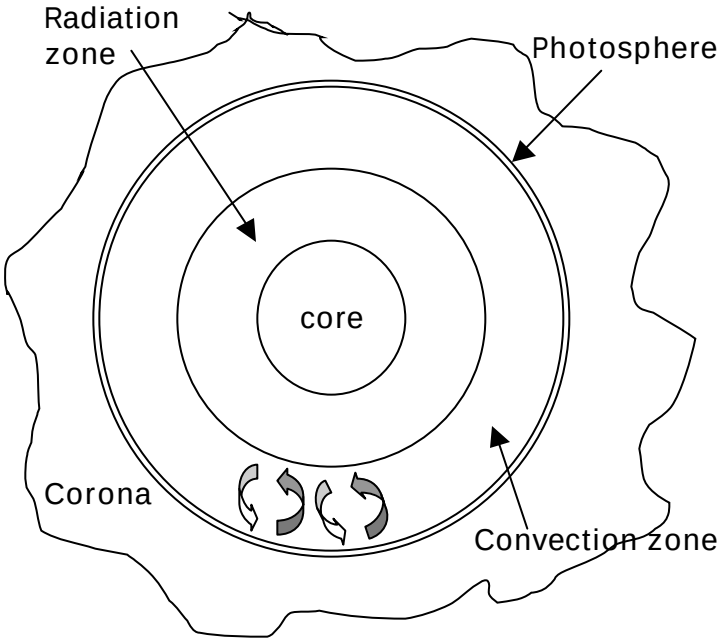
1. **Why are sunspots cooler than the surrounding solar surface areas?**
   The high magnetic pressure inside sunspots forces the hot plasma out, so that pressure is balanced. The matter in the sunspot interior thus becomes less dense and somewhat cooler.

2. **Describe the umbra and penumbra of a sunspot and tell what makes each part a different color.**
   Sunspots have a central shadow or "umbra" area that is somewhat cooler and relatively dark because of magnetic exclusion of the plasma. This is surrounded by a lighter "penumbra," which is a little warmer.

3. **How long does it take a photon to migrate from the Sun's core to its surface, and why?**
   This process can take a million years or more, because each photon is scattered many, many times by the protons in the hydrogen plasma inside the Sun.

4. **Where is 99.8% of the solar system's mass, and what two elements is it made of (mostly)?**
   Nearly all the solar system's mass in the Sun, and it consists almost entirely of hydrogen and helium.

5. **Draw a diagram of the Sun's interior, labeling five major zones. What is happening in each?**



Core: nuclear fusion turns hydrogen into helium.

Radiation zone: energy travels outward as photons through a dense plasma, making it very hot.

Convection zone: energy is transferred toward the surface as thermal energy in circulating plasma.

Photosphere: visible light is emitted at about 5800 K.

Corona: very hot gas emits x-rays (possibly because of interactions with the Sun's magnetic field).

6. **What happens in the convection zone and why?**
   Energy is transferred toward the surface as thermal energy in circulating plasma. Beneath, at the boundary with the radiation zone, energy from fusion in the core heats the plasma, which starts moving upward toward the cooler photosphere. At the photosphere, energy escapes as the Sun's visible spectrum, cooling the plasma, which then sinks back toward the radiation zone.

7. **What is the sunspot cycle? How long is it? What happens?**

A regular variation in the average number of sunspots. Sunspots decrease and then increase again over about 11 years, then the Sun's magnetic dipole field reverses, and the cycle repeats, for a total cycle time of about 22 years. As sunspots appear more and more frequently near the peak of solar activity, they also tend to move toward the Sun's equator from the higher latitudes.

8. **What role do sunspots play in solar flares and coronal mass ejections (CME's)?**
   Sunspots are the places where dense loops of magnetic field emerge from and re-enter the surface. These intense fields are created by whirling eddies and "cyclones" of charged plasma material. These loops may break or collapse, causing large volumes of energetic particles to be discharged as the Sun's magnetic field re-stabilizes itself. These solar explosions are flares and CME's.

9. **How can geomagnetic storms affect satellites and communications on Earth?**
   By damaging satellite electronics as they pass through current sheets formed in the ionosphere
   By disrupting radio, television, and telephone transmissions.
   By creating fluctuating magnetic fields that can overload power utility grids and cause transformer blow-outs.

10. **Might sunspot activity affect the Earth's weather patterns? What are your reasons for the answer you gave?**
    Yes, it might. A very active sunspot cycle might affect the production of ozone or other chemical processes in the outer atmosphere. Some correlation has been noted between solar activity and Earth temperatures, but the Earth and its atmosphere are very complex and the effects of the Sun and human activity on them are not yet understood.