The first ten questions are qualitative and examine your basic knowledge of MEMS and BioMEMS, they all have short answers. If needed, you can draw a schematic to explain your answers.

1) Name 5 MEMS or BioMEMS devices that have been successfully commercialized (5 points)

2) In bringing a MEMS sensor to the market what is the most expensive part of the development process, (i) design, (ii) fabrication, or (iii) test and packaging? (5 points)

3) Which of the following wet silicon etchants have the best p++ etch stop selectivity, EDP, KOH, or TMAH? (5 points)

4) What is the best masking material if you want to etch silicon with KOH? (silicon dioxide, silicon nitride, photoresist, gold, or polysilicon) (5 points)
5) Name two process issues one has to be mindful of when choosing a sacrificial layer etchant for a surface micromachining process. \(5\) points

6) Name two methods that can be used to measure a thin film Young's modulus. \(5\) points

7) Name two advantages of resonant sensors (sensors which are based on a resonating mechanical structure such as a beam) \(5\) points

8) What is parylene? How is it deposited? Name two advantages of parylene for biomedical applications? \(5\) points
9) How is the hole/trench shown below is etched in silicon? (Wet or dry? what chemistry or method??) Explain the reasons behind your choice. (5 points)

10) Give an estimate of the dimensions of the following biological molecules or organisms (5 points)
- Diameter of a DNA molecule
- A typical protein molecule like hemoglobin or antibody
- A virus like flu
- A bacterial like E. coli
- A mammalian cell
11) Picture below shows a photograph of a silicon multi-electrode array known as "Utah Array" used for recording and stimulation of neurons. How was this fabricated? Propose a possible fabrication scheme for this. The white tips are metallic (possibly platinum or gold) and are insulated except at the tip. Pay close attention to the scale bar and the length of the electrodes. How can you carve out electrodes with this aspect ratio? Can you use wet or dry etch? If not how to do this? How to sharpen the tips? How to make electrical connection to the backend? (20 points)

Your proposed fabrication method does not have to be the exact one they used but it has to make sense.
12) What is Reynolds' #? (write it if you remember all the terms. If not write it as a ratio of forces it signifies) What does it signify? Give one example of flow at high Reynolds' # (let's say > 10,000) and one at low Reynolds # (let's say <0.01). What is its importance in microfluidic and name one example in that context that it can be advantageous and one in which it can cause problems. *(10 Points)*
13) Which one of the four configurations for a piezoresistive cantilever sensor has the best sensitivity? Justify your answer and also explain what is the issue with others you did not choose? (10 Points)
14) Microneedle arrays fabricated using a variety of MEMS methods have been investigated for drug delivery across the skin for more than a decade. What are these typically made of (name 2 or 3 materials that have been used most often)? Figure below shows four ways one can deliver chemicals across the skin, briefly explain how each works? *(10 Points)*