The following questions are of the kind that may come up in the exam this year. They are designed to help you monitor your progress – try to answer the questions without your notes, and then use your notes to check whether your answers are correct. The percentages indicate the corresponding fraction of a 1.5 hour exam.

**Question 1**

(a) Dimensionality reduction is a form of data compression. What does this statement mean? Is it always true?  
(b) Describe a practical example of when and why it would be useful to perform some form of compression on a set of data.  
(c) Explain in detail how one can carry out dimensionality reduction using a simple Multi-Layer Perceptron (MLP).  
(d) Describe in detail how one can carry out dimensionality reduction using a Self Organizing Map (e.g., a Kohonen Network).

**Question 2**

(a) Explain what is meant by the term Topographic Map. Give an example of where such a map can be found in the human brain, and outline why it might be useful there.  
(b) Describe the key components of the architecture and self-organizing process that can be used to generate topographic maps in a Kohonen Network.  
(c) Give intuitive explanations of why the size of the topological neighbourhood and the learning rate should both be decreased during a course of successful Kohonen Network training.

**Question 3**

(a) In general, what is meant by the term Self Organising Map (SOM)?  
(b) Describe the particular form of Self Organising Map (SOM) that is generated by a Kohonen Network.  
(c) Outline the main components of the self-organising process used to train a Kohonen Network, and comment on the possibility of a Topological Defect arising.  
(d) In the context of Kohonen Networks, explain what is meant by the terms Density Matching and Topological Ordering, and why they are important features of the self organised mapping.
Question 4

(a) Describe the architecture of the Self Organising Map (SOM) known as a Kohonen Network. [4%]

(b) What kinds of applications can such networks be used for? Outline one concrete example application. [5%]

(c) The self organising process can be said to have four major components: Initialization, Competition, Cooperation, and Adaptation. Briefly describe the purpose of each of these components and how they can be implemented. [8%]

(d) Two equations used in the context of Kohonen Networks are:

\[
T_{j,I(x)}(t) = \exp\left(-S_{j,I(x)}^2 / 2\sigma^2(t)\right)
\]

\[
\Delta w_{ji} = \eta(t) \cdot T_{j,I(x)}(t) \cdot (x_i - w_{ji})
\]

What do each of the symbols in them mean, and how are these equations used in the self organising process? [8%]

Question 5

(a) By definition, there are no target output values in unsupervised learning. So, what exactly is learned by an unsupervised learning process? [4%]

(b) Explain the structure of the various layers of neurons in a standard Kohonen Network, and what each layer of neurons represents or computes. [4%]

(c) Describe the key steps in the standard unsupervised training algorithm that can be used to result in a Kohonen Network producing useful outputs. [7%]

(d) Explain the relation between a Kohonen Network and a Noisy Encoder-Decoder Model, and what that implies about the mapping performed by a Kohonen Network. [10%]

Question 6

(a) Describe the data compression properties of the mapping that is performed by an appropriately trained Kohonen Network. [8%]

(b) In this context, explain what is meant by the terms Vector Quantization and Voronoi Tessellation. [7%]

(c) Outline how Learning Vector Quantization (LVQ) can improve the performance of a Kohonen Network. [10%]