1. List three main use case scenarios introduced by 5G

   - Enhanced Mobile Broadband (eMBB)
   - Ultra reliable and low Latency Communications (uRLLC)
   - Massive Machine Type Communications (mMTC)

2. What is the main goal of ultra reliable and low latency communications (uRLLC)?

   - uRLLC address the human centric use cases for access to multi-media content, data and services

3. List three application areas requiring eMBB

   - Augmented reality (AR)
   - 360° video streaming
   - Immersive virtual reality

4. Briefly explain the trade-off between achieving an ultra-low latency and a high reliable communication at once

   - Improving the reliability required the use of more resources for signaling , re-transmission and redundancy which might result in an increase of the latency

5. Describe the Non-Standalone (NSA) deployment scenario of 5G

   - See lecture slide 11

6. What is the motivation behind the introduction of 5G-New Radio (5G-NR)?

   - New air interface developed for the 5G network supporting adaptive bandwidth
     - Devices can move to a low bandwidth, low power configuration when appropriate, and gearing up to higher bandwidths only when necessary
   - It encompasses agile frame structure, high frequencies , new multiple access techniques for

7. List two features of 5G-NR

   - Beamforming
   - Millimeter wave

8. What is beamforming?

   - It is the manipulation of the signals fed to and received from complex antennas to create beams in space that focus power in a particular direction

9. List two main challenges faced by millimeter wave in V2X environments

    - Increasing overhead for the beam training as it might be difficult to properly align beams under high mobility and shadowing
    - Blockage effects due to pedestrian bodies and infrastructure elements

10. What is the goal of 5G-V2X?

    - Designed to support V2X applications that have varying degrees of latency, reliability and throughput requirements
    - Supplement C-V2X in supporting those use cases that cannot be supported by C-V2X

11. List three main objectives of 5G-V2X

    - Re-design sidelink procedures in order to support advanced V2X applications
    - Identify enhancements to the NR Uu interface to support advanced V2X applications
    - Study mechanisms to identify the best interface (among C-V2X sidelink, 5G sidelink, LTE Uu) for given V2X message transmission

12. What is in-device coexistence?

    - Coexistence of C-V2X and 5G-V2X within a single device

13. What is the task of 5G-V2X sidelink feedback channel?

    - New feedback channel introduced to enable feedback based re-transmissions and channel state information acquisition for sidelink transmission

14. What is the drawback of blind-retransmission used by C-V2X?

    - It is inefficient as a node might proactively retransmit for a predetermined number of attempts even if the initial transmission was successful

15. List the new introduced sub-modes of sidelink mode 2

    - Mode 2 (a): Each UE autonomously selects its resources
    - Mode 2 (b): UEs assist other UEs in performing resource selection
    - Mode 2 (c): UEs use pre-configured sidelink grants to transmit their messages
    - Mode 2 (d): UEs select resources for other UEs

16. How does the sidelink mode 2(a) work?

- Sidelink mode 2(a) introduces a flexible duration of the sensing window based on vehicular mobility and introduce long-term and short-term sensing in order to decrease the channel access delay and hence the overall end-to-end latency

17. How does long-term/short-term sensing in sidelink mode 2(a) work?

    - UEs perform sensing and resource exclusion over the sensing window and select a transmission resource within the selection window. However, before transmitting, the UE must perform short-term sensing to detect the presence of other signals on its selected resource using e.g., Listen Before Talk protocol

18. What is the role of scheduling-UE (S-UE) in sidelink mode 2(b)

    - S-UE performs resource allocation for a group of UEs in its vicinity

19. How to select the S-UE?

    - Geo-location based selection of S UE
    - Pre-configuration based S-UE selection

20. How does the pre-configuration based S-UE selection work?

    - Vehicles with additional hardware/processing capabilities can take on the responsibility of resource allocation for surrounding vehicles

21. What is the main challenge of sidelink mode 2(b)?

    - Interference mitigation between neighboring UEs that are assigned resources by different S-UEs, e.g., platoons catch-up

22. Describe the coexistence issue between C-V2X and 5G-V2X

    - C-V2X devices operating at 15 kHz sub carrier spacing, cannot decode messages transmitted using the 30 or 60 kHz spacing from 5G-V2X devices

23. List two main mechanisms enabling the coexistence of C-V2X and 5G-V2X

    - Frequency division multiplexing (FDM)
    - Time division multiplexing (TDM)

24. What are the challenges of the time division multiplexing (TDM) enabling the coexistence of C-V2X and 5G-V2X?

    - Increased delays as for latency critical use cases one interface may be off
    - Severe restrictions on time synchronization between both technologies is required

25. How to deal with the co-existence of C-V2X and ITS-G5/DSRC?

    - Regulatory agencies must permit only one V2X technology (either DSRC or C-V2X) to operate in a vehicle within a given geographical region

26. How to enable an interoperability between C-V2X and 5G-V2X?

    - New vehicles shall deploy both C-V2X and 5G-V2X to enable the interoperability with old vehicles

27. How to cope with the coexistence issue between ITS-G5/DSRC and WiFi?

    - Adaption of MAC protocol: Increase of the contention window size and/or Inter-frame space of Wi-Fi so that the priority of Wi Fi transmissions is reduced

28. How does 5G-V2X support fully automated driving?

    - 5G V2X can create a vehicle's collective perception of the surrounding environment by helping to achieve more informed and accurate decisions, based on exchanged local views and planned maneuvers from nearby vehicles instead of relying on local awareness built upon on-board sensors only

29. Describe the high density platooning use case?

    - Operation of a group of vehicles in a closely linked manner such that the vehicles move like a train by reducing distance between vehicles in order to reduce the overall fuel consumption and the number of needed drivers

30. What is the motivation behind the introduction of 5G-V2X-based use case remote driving?

    - Remote driving enables a remote driver to operate a remote vehicle for those passengers who cannot drive themselves or a remote vehicle located in dangerous environments

31. What is collective perception?

    - By exchanging raw or processed data gathered through local sensors or live video data among vehicles, they can enhance the perception of their environment beyond what their own sensors can detect and have a more holistic view of the local situation